Volume 12 JULY 1928 Number 7

BULLETIN

of the

American Association *of* Petroleum Geologists

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THE BULLETIN

of the

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

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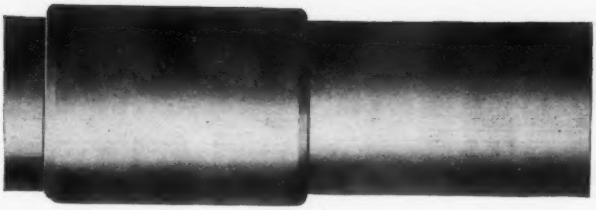

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JULY, 1928

GEOLOGY OF SOUTHWESTERN MENDOZA PROVINCE, ARGENTINA[1]

KENNETH AID[2] AND A. J. BAUERNSCHMIDT, JR.[3]
Dallas, Texas

ABSTRACT

Sedimentary rocks of Jurassic, Cretaceous, and Tertiary age are widely exposed along the eastern flanks of the Andes in southwestern Mendoza province. These rocks were studied and correlated as far as possible with Lahee's section in central-western Mendoza.

The sediments are covered in many places by andesitic and basaltic lava flows and are much folded, faulted, and tilted.

As a rule the oil seeps of central-western Mendoza are associated with igneous intrusions, while in the southern part of the province they are associated with faults.

The most favorable structures for oil accumulation in this area appear to be faulted anticlines.

INTRODUCTION

The purpose of the writers is to present a brief outline of the geology of that portion of the province of Mendoza, Argentina, which extends along the eastern flanks of the Andes from Rio Salado to Rio Barrancas.

As the greater part of this territory was covered by a hasty reconnaissance survey, most of the work was of necessity done from horseback. Such observations as were necessary were made with a Brunton compass, clinometer, barometer, and hand level, and distances were generally estimated, paced, or measured with a steel tape. The field work was done in November and December, 1926, and during that time the authors were able to examine hastily a large part of the entire area.

[1]Manuscript received by the editor, April 29, 1928.

[2]Gallatin, Missouri.

[3]Sun Oil Company, American Exchange National Bank Building, Dallas, Texas.

Thanks are due F. H. Lahee for reading the manuscript and to the Sun Oil Company for permission to print this report.

LOCATION

The territory explored lies in the south-central part of the department of Malalgue, province of Mendoza, Argentina. On the north the area is bounded by Rios Salado and Atuel, on the east by Lago Llancanelo and Rio Grande, on the southwest by Rio Barrancas and on the west by the international boundary line between Argentine and Chile (Fig. 1).

GEOGRAPHY

This area may be conveniently divided into three physiographic provinces, namely, the Cordon, the Foot-Hills, and the Plains. Each of these provinces is characterized by a different type of topography. On the extreme west is the Mountain belt, in the center and southwest is the Foot-Hills belt and on the northeast is the Plains belt. The country in the Mountain belt is very rugged and includes the high snow-capped peaks of the main Andean cordillera. Hills of much less relief characterize the Foot-Hills belt and these terminate rather abruptly in the northeastern part of the area in a pronounced fault scarp. East of this scarp lies the Plains belt, which consists of gently sloping alluvial plains broken here and there by hills of igneous origin.

The northeastern corner of this area is about 100 miles from the railroad at San Rafael, and the southwest corner is approximately 200 miles from the station Cipaletti on the Southern Railroad Territory Neuquen.

TOPOGRAPHY

The topography is for the most part very rough (Fig. 2). Along the western border the mountains are very rugged with a gradual diminution in roughness as the plains are approached. Elevations above sea-level range from 11,200 feet on the west to 4,300 feet on the east. The average relief is approximately 6,500 feet. Slopes range from 20° to almost vertical in the mountains and from 2° to 4° on the plains.

The region is considerably dissected by rivers and tributary streams. Rio Grande and Rio Barrancas are deeply entrenched in the older formations, having cut down thousands of feet below the old Tertiary surface. Tributaries entering the larger rivers are short and enter the main streams almost at right angles, which is characteristic of youthful topography.

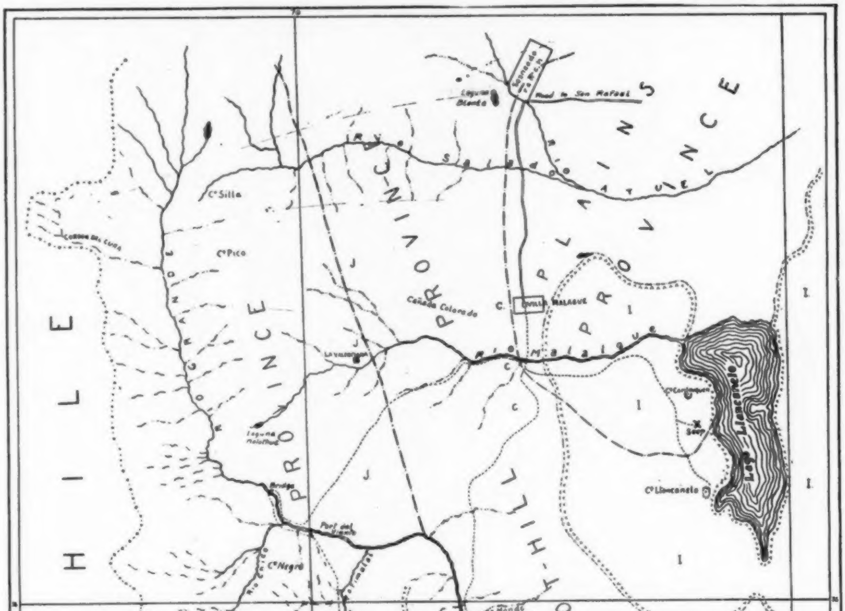

FIG. 1.—Map of west-central part, Department of Malalgue, Province of Mendoza, Argentine.

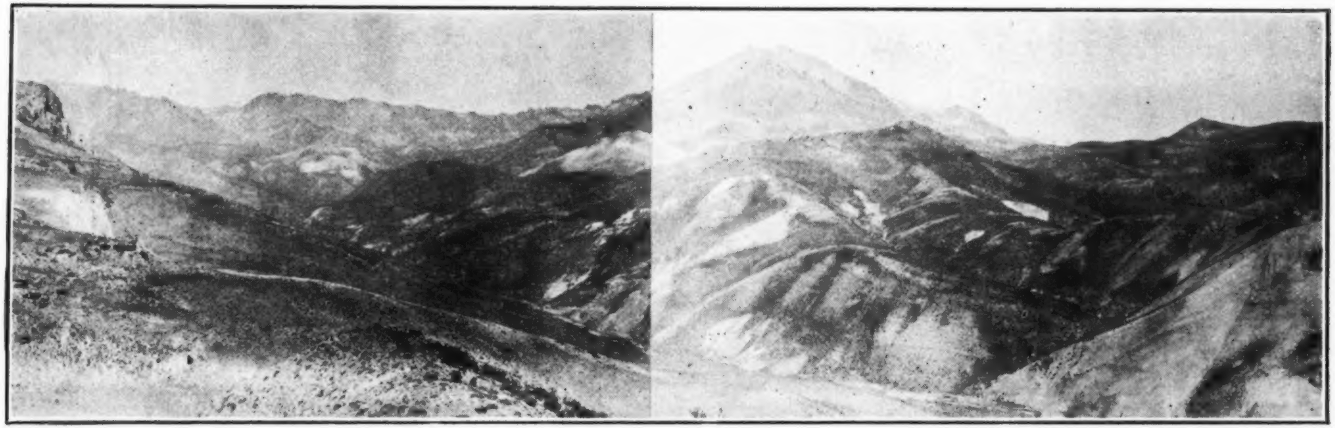

FIG. 2.—View of Cordon de Mary looking west. In the upper left corner can be seen lava; in the lower right corner are folded Jurassic sediments.

The old Tertiary plain, of which remnants are seen on the divides, slopes westward due to a downfaulting on the west and an uplifting on the east.

DRAINAGE

All surface waters in this region drain into five rivers: Rios Atuel, Salado, Malalgue, Grande, and Barrancas. Rio Grande is the principal stream of the area and is the largest river in the province of Mendoza. All the larger streams are permanent, and most of the tributaries are supplied with water in the summer months from melting snow.

Remnants of the old Tertiary surface cap the divides. At one time this old surface was probably a continuous plain, but it has long since been dissected by many streams which traverse the area. Rocks exposed in the stream beds in the western part of the region are older than those found along the beds of the streams in the east. This indicates some sort of differential movement. The presence of benches of river gravel along the streams also indicates a regional uplift. Therefore, movements of several kinds have occurred here at times in the past.

GEOLOGY

In general the areal distribution of the formations is a parallel succession of beds, a result of normal uplift. This regular succession, however, is broken by faults and dikes and is obscured, except in the river valleys, by a covering of late Tertiary agglomerates, volcanic ash, and valley lava flows.

Jurassic and probably older strata are exposed in the west, and as the east is approached the rocks become younger and younger in age. Intense folding, faulting, and igneous activity have made the structure so complex that it is difficult to trace the various formations for any distance. However, the Ammonite shales (Jurassic) can be traced all along the Andes in this region. This formation has therefore served as a key horizon.

STRATIGRAPHY

Sedimentary rocks are best exposed in the river valleys where erosion has removed the Tertiary lava flows, which cover most of the region. The following classification is based on lithologic differences and fossil content of the rocks.

LATE TERTIARY

Escarpment series.—This series is exposed in the high country and consists of gray agglomerates made up mostly of igneous materials,

such as andesite dikes, sills, basaltic lava flows, and white volcanic ash (Figs. 3 and 4). This series is very similar to the upper part of the Ranch-House conglomerates[1] of central-western Mendoza.

FIG. 3.—The thick Escarpment series, looking west from Rio Barrancas.

FIG. 4.—Lava flows along Rio Grande. View looking south.

[1]F. H. Lahee, "The Petroliferous Belt of Central-Western Mendoza Province, Argentina," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 11 (1927), pp. 261-78.

MIDDLE TERTIARY

Seco series.—This series is exposed in the valley of the Arroyo Seco, a stream flowing east from a salt mine in the southeastern part of the area. It consists of red shales toward the top and red sandstones near the base. This formation is unfossiliferous and is probably of continental origin. These red shales and sandstones, together with the Puntillas series, may be correlated with the lower part of the Ranch-House conglomerates of the area to the north.[1]

LOWER TERTIARY

Puntillas series.—The Puntillas sandstones are exposed at Vega de las Puntillas. They consist of yellow and white, highly cross-bedded sandstones, interstratified with thin red shales, and thin fossiliferous limestone. Fossil wood is also common.

UPPER CRETACEOUS

Ranquil series.—This formation is well exposed along Arroyo Ranquil (Fig. 5) and has a rather wide distribution in the high country between Rio Grande and Rio Barrancas. The basal part of the series is red shales with thin beds of gypsum and fossiliferous limestones, followed by a thick series of variegated shales. This series corresponds to the Ramadas series of central-western Mendoza.[1]

FIG. 5.—Isoclinal fold in Arroyo Ranquil. The low scarp in the middle of the picture is the edge of a lava flow. View looking southeast.

[1] *Op. cit.*

MIDDLE CRETACEOUS

Barrancas series.—This series is well exposed on both flanks of the Chacaico anticline and along the northeast side of Rio Barrancas, extending for miles down the river. It is composed of about 800 feet of massive, cross-bedded, brown sandstone alternating with chocolate and green shales. No fossils were found in this series, but its position above the limestone and gypsum series places it probably in the Middle Cretaceous. This sandstone and shale series is equivalent to the Salas sandstone of central-western Mendoza.[1]

UPPER CRETACEOUS OR UPPER JURASSIC

Batro series.—The type section of this series is found along Rio Barrancas west of the settlement of Batro. It lies immediately above the black shales and is composed of beds of massive gypsum at the base, with thin limestone members and interbedded shale, gypsum, and brown sandstones toward the top. The limestone is extremely hard, unfossiliferous, and contains solidified petroleum along bedding planes and in fractures. The Batro series is believed to be of the same age as the Diamante limestone farther north.[1]

UPPER JURASSIC

Ammonite shale series.—This black shale series was used as the key horizon and was traced south from the El Sosneado district in west-central Mendoza province.[1] These shales are very fossiliferous, rather soft, and range in color from light gray to black. In some sections the natives call these black shales coal. Near the base the shales are sandy, while near the top they are limy. Many rounded limy concretions, all of which contain fossils, occur in the more shaly portions.

STRUCTURE

General.—Practically every type of structure is represented in this region. Much folding took place in Tertiary time with a general tendency toward overturning eastward. The older rocks, exposed along the western border, are much more intensely folded than the younger rocks on the east. The continuity of the formations is broken by faults and igneous dikes which cut the strata at all angles (Fig. 6). There are many minor or local faults, but a few are of major importance. The strata have a general southeastward dip, exposing the older rocks in the west and the younger rocks in the east. This indicates that a great block

[1] *Op. cit.*

FIG. 6.—Andesite dikes cutting sediments south of Malalgue. View looking southeast.

has been uplifted on the west and downtilted on the east. The entire region, with the adjacent territory to the north and south, seems to be a zone of faulting, with the direction of major faulting parallel to the axis of the main Andean range. The area between Rio Grande and Rio Barrancas is a downthrown fault block, the rivers following more or less the direction of major faulting.

Local.—There is a faulted anticline in the channel of Rio Barrancas near Arroyo Chacaico about 3 miles north of El Batro. Rio Barrancas flows along its axis and has exposed, by erosion, rocks ranging from Upper Jurassic to Upper Cretaceous in age. A fault upthrown on the northeast follows the course of the river, almost paralleling the axis of the anticline. Beginning on the upthrown side of the fault there are first exposed the Ammonite shales (Upper Jurassic), cut by two andesite dikes a few meters apart; above this shale series comes the gypsum, shale, limestone, and sandstone series of the Lower Cretaceous, which in turn is overlain by the Barrancas sandstone and shales of Middle Cretaceous age. On the downthrown side of the fault the Ammonite shale series and most of the gypsum and limestone series are buried. Only the upper few meters of the Lower Cretaceous formation and all of the Middle Cretaceous formation are exposed on this side of the fault.

An oil seepage occurs in the river alluvium directly in line with the fault. The oil is probably seeping up the fault from a horizon just above

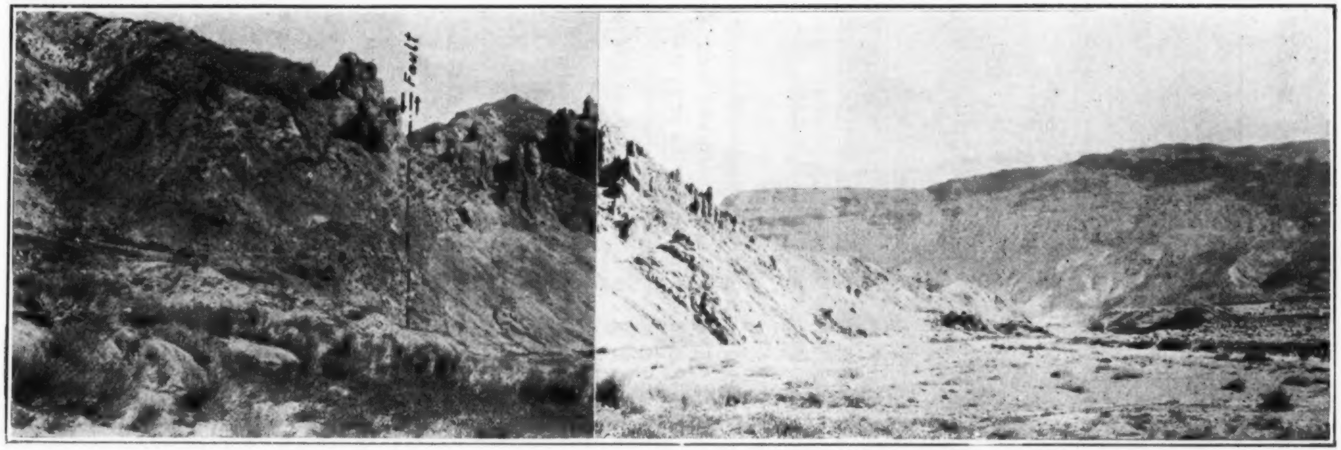

FIG. 7.—View of faulted Chacaico anticline at seepage above El Batro. At right are river terraces along Rio Barrancas. Looking southeast.

the Ammonite shales. Two dikes which cut through the shales may be partly responsible for the oil at the seepage, the heat and pressure exerted by the intrusion forcing the shales to give up part of their original oil content.

The Arroyo Camino anticline is in the channel of Arroyo Camino, a tributary of Rio Barrancas. A fault which is upthrown on the west cuts through the heart of the fold, paralleling its axis. Erosion by stream action and uplift due to folding and faulting has exposed the Lower Cretaceous limestone and gypsum series along the crest of the structure.

EVIDENCE OF PETROLEUM

Three oil seeps were found along Rio Barrancas and one on the west shore of Lago Llancanelo. The largest seep is about one league above Batro, near the junction of Arroyo Chacaico and Rio Barrancas, along the axis and fault of the Chacaico anticline (Fig. 7). The oil seeps out of river gravel only a few feet from the edge of the water, is light and is coming up along the fault either directly from the Ammonite shales or from a horizon in the Batro series which overlies the shales.

About two leagues below Batro on Rio Barrancas are two seepages of less importance. However, at one time large seeps were reported to be present at these localities. Judging from the structure and the section exposed, the occurrence is similar to the seepage above Batro.

FIG. 8.—Oil seep on west shore of Lago Llancanelo. View looking southeast.

Another seep is located in the marshlands on the west shore of Lago Llancanelo (Fig. 8), between Cerro Carilauquen and Cerro Llancanelo. This is a heavy asphaltic base oil, of doubtful origin, as there are no sedimentary rocks exposed for miles around.

STRATIGRAPHY OF WEATHERFORD AREA, OKLAHOMA[1]

NOEL EVANS[2]
Ponca City, Oklahoma

ABSTRACT

The rocks exposed in the Weatherford, Oklahoma, area belong to the Permian series. They include in ascending order: the Dog Creek shale, Whitehorse sandstone, Day Creek dolomite, Cloud Chief gypsum, and the Quartermaster formation.

The zone between the Day Creek dolomite and the massive Cloud Chief gypsum, just west of Weatherford, consists of about 60 feet of loosely cemented sandstone beds and gypsum lentils. These gypsum lentils disappear and the thickness of the zone decreases toward the south. The depositional basin of Day Creek and early Cloud Chief time had its greatest depth northwest of the town of Weatherford.

The Quartermaster formation rests unconformably on Whitehorse sandstone, Day Creek dolomite, and, farther west, on Cloud Chief gypsum. Dolomite beds which cap the Caddo County buttes, southeast of Weatherford, belong to the Quartermaster, not to the Day Creek. These beds are unreliable for detailed structural work.

INTRODUCTION

In various discussions of the Permian rocks of western Oklahoma[3] the term Day Creek has been applied to many more or less isolated exposures of thin light-colored dolomites lying on or near a series of red sands and shales considered to be of Whitehorse age. It has generally been assumed that these dolomites are equivalent, the evidence for such correlation being that they are lithologically similar and appear to be underlain by beds of Whitehorse. It is the purpose of the writer to point out that in the Weatherford area these dolomites can be shown to occur at three different horizons, one near the top of the lower member of the Whitehorse, one at or near the top of the upper member of the Whitehorse, and the third at the base of the Quartermaster.

[1]Presented before the Association at the San Francisco meeting, March 22, 1928. Manuscript received by the editor, March 25, 1928. Published by permission of the Marland Oil Company of Oklahoma.

[2]Geologist, Marland Oil Company.

[3]C. N. Gould, *U. S. Geol. Survey Water Supply Paper 148* (1905), p. 57. L. C. Snider, *Okla. Geol. Survey, Bull. 11* (1913), pp. 122-23. Fritz Aurin, *Okla. Geol. Survey Bull. 30* (1917), pp. 28-30. Frank Reeves, "Geology of the Cement Oil Field," *U. S. Geol. Survey Bull. 726B* (1921), p. 49. C. N. Gould, *Okla. Geol. Survey Bull. 35* (1925), p. 94. C. N. Gould, *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 8 (1924), p. 337.

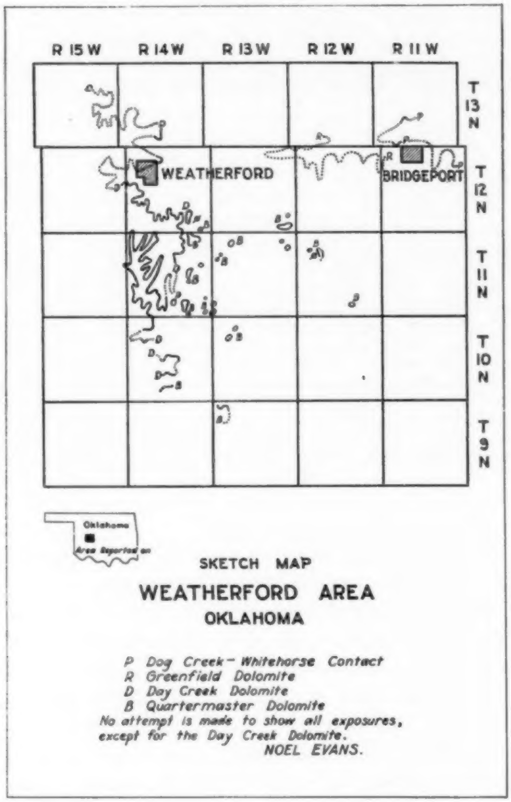

Fig. 1.—Sketch map, Weatherford area, Oklahoma. Scale: one township, approximately 6 miles square.

The area discussed in this paper is located in T. 9-13 N., R. 11-15 W., inclusive. The town of Weatherford is in Sec. 8, T. 12 N., R. 14 W., near the northwest corner of this area.

STRATIGRAPHY

The rocks exposed in this area, except some Tertiary gravels and Quaternary sands and alluvium, belong to the upper part of the Permian. They include the Dog Creek shale, Whitehorse sandstone, Day Creek

dolomite, Cloud Chief gypsum, and Quartermaster formation, in ascending order.

Dog Creek shale.—The Dog Creek shale in this area is a true red shale with white sandy streaks. The uppermost 4 feet is generally made up of red shale with irregular gypsum veins. These veins cut across the bedding planes at all angles, giving this part of the formation a very characteristic appearance. There are few places where the contact of this formation with the overlying Whitehorse may be found, but where found it is sharp and distinct, going from a true red shale to a reddish-buff sandstone. Only the uppermost part of the Dog Creek is exposed in this area. The Dog Creek-Whitehorse contact can be found in Sec. 5, T. 12 N., R. 11 W., a few hundred yards west of the railroad station at Bridgeport, Oklahoma. This contact also occurs in the SW. 1/4, Sec. 12, of this same township.

Whitehorse sandstone.—Above the Dog Creek shale is the Whitehorse sandstone. This formation can easily be subdivided into two members: a lower member of approximately 115 feet and an upper member of about 380 feet. Sawyer[1] suggests the names Whitehorse for the upper and Marlow for the lower. Stephenson,[2] in his author's note on the "Verden Sandstone of Oklahoma," suggests that the Whitehorse be divided into three members: Upper, Middle, and Lower. In the Weatherford area it is difficult to separate the Middle Whitehorse, as defined by Stephenson, from his Upper Whitehorse and Lower Whitehorse. For this reason, the writer has used only two divisions, which he has called Upper Whitehorse and Lower Whitehorse.

The Lower Whitehorse consists of red sandstone with shaly layers. Some of the sandstone beds are gypsiferous, and, generally, they are not nearly so cross-bedded as the sandstone of the Upper Whitehorse. A dolomite or calcareous bed occurs about 15 feet below the top of the Lower Whitehorse. This bed ranges in thickness from almost nothing to possibly 2 feet, and in color from light gray to nearly black. This calcareous bed is correlated with the Greenfield limestone of Stephenson's[3] section. A good exposure of this bed occurs near the northeast corner of Sec. 2, T. 12 N., R. 12 W.

The Upper Whitehorse is composed of approximately 380 feet of poorly cemented, highly cross-bedded, fine-grained, reddish-buff sandstone, which covers the greater part of this area. This member weathers

[1]Roger W. Sawyer, *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 8 (1924), p. 317.

[2]C. D. Stephenson, *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 9 (1925), p. 631.

[3]*Op. cit.* pp. 629, 630.

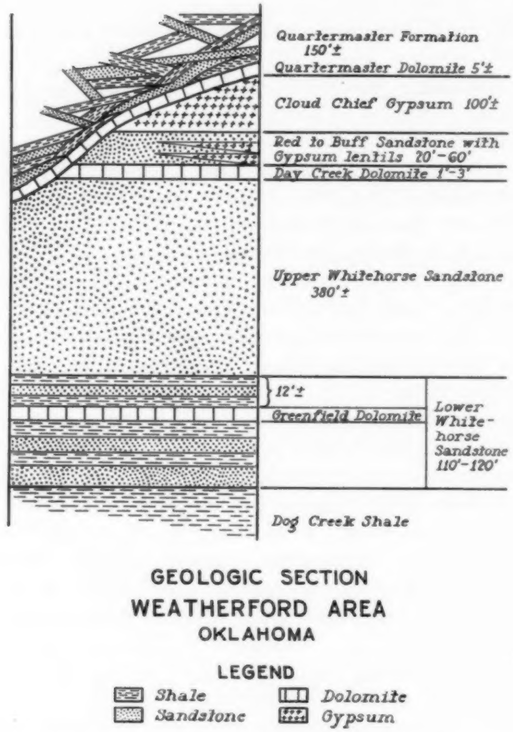

FIG. 2.—Geologic section, Weatherford area, Oklahoma. Thickness shown in feet.

rapidly to a loose sandy soil and it is only in the steep-sided stream walls or bluffs that good exposures are common. The writer knows of no place in the area where shale occurs in the Upper Whitehorse.

Day Creek dolomite.—The Day Creek dolomite is typically a hard light gray dolomite with a maximum thickness of 3 feet, but in most places approximately 1 foot thick. It is commonly laminated or banded and in places the lamination planes are distorted or folded, resembling fossil wood. The contact with the Whitehorse is regular and is conformable to beds that are 40 feet below. The Day Creek dolomite is an exceptionally good marker. Its outcrops extend from the area 1 mile south of the town of Weatherford in T. 12 N., R. 14 W., south across T. 11 N., R. 14 W., and a part of T. 10 N., R. 14 W.

From the town of Weatherford west and northwest the Day Creek horizon is represented by a gypsum bed ranging from 3 to 10 feet in thickness. This gypsum is rather white or gray with little or no pinkish or red color. The lower 3 feet is well bedded or banded, but the upper part is generally of the massive type. The lower 3 feet is the equivalent of the Day Creek dolomite. The bed is well exposed on the main highway at the northeast corner of Weatherford.

Sandstone in position, and below the massive Cloud Chief gypsum, occurs above the Day Creek dolomite. This sandstone is, apparently, Whitehorse. At Weatherford this sandstone contains some gypsum lentils and occupies a zone of about 60 feet between the Day Creek horizon and the massive Cloud Chief gypsum. The sandstone beds are lithologically similar to the Whitehorse below the Day Creek. They have the same color and are composed of fine-grained sand which is poorly cemented, except where gypsiferous. They are also cross-bedded, though possibly not so highly cross-bedded as the Whitehorse. At the south the thickness of this zone decreases and the intervening gypsum lentils disappear.

The fact that sandstone occurs above the dolomite may cause some geologists to question the identity of this dolomite with the Day Creek. However, this condition proves that the bed occupies a true stratigraphical position at or near the top of the latest Whitehorse. The writer holds the opinion that the dolomite here described is the true Day Creek.

Cloud Chief gypsum.—The Cloud Chief gypsum is well developed in this region, having a thickness of 100 feet or more of massive pinkish-white gypsum. This formation is the only one exposed in this area, except the zone just below it, that consists of, or contains, much gypsum. If there are beds of shale or sandstone between gypsum beds, they are not exposed so as to make them conspicuous. The stratification of this formation has been described by Gould[1] as being very irregular, the beds "thickening rapidly or disappearing without apparent regularity." The writer thinks that much of this apparent irregularity is due to an erosional unconformity at the end of Cloud Chief time, this erosion having removed a part of the gypsum so that later deposition placed Redbeds in adjacent positions.[2]

More details regarding this erosional unconformity will be found under the discussion of the Quartermaster formation in this paper.

Quartermaster formation.—The Quartermaster formation consists of about 150 feet of red sandstones and shales. Most of the sandstone beds

[1] C. N. Gould, *U. S. Geol. Survey Water Supply Paper No. 148* (1905), p. 59.

[2] C. N. Gould, *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 8 (1924), p. 339.

are thin, well-bedded, blocky sandstones, interbedded with red shale; however, some are rather massive. There are white sandy streaks, which one soon notices as being characteristic of the Quartermaster. These white streaks are soft or shaly where interbedded with soft sandy and shaly beds and they are hard and blocky where interbedded with hard blocky sandstones. The high, irregular dips so characteristic of the Quartermaster elsewhere are also present. This formation presents a real problem in this area. It is unconformable over the lower beds, in some places resting directly on Whitehorse sandstone, and in other places occurring at higher elevations than the Cloud Chief gypsum. The writer remembers no place in the area where Quartermaster beds rest directly on the Cloud Chief. However, there are several places where the two formations are only a short distance apart, with the Quartermaster extending much higher in elevation. More details regarding this unconformity follow.

It is to the Quartermaster that the writer wishes to call particular attention. In the SW. 1/4, Sec. 29, T. 11 N., R. 14 W., the Quartermaster rests directly on the Day Creek dolomite. Another good exposure of these beds is in the high hill in the NW. 1/4, Sec. 30, T. 11 N., R. 14 W.

Quartermaster beds occur in Sec. 5, T. 9 N., R. 13 W. Here they rest directly and unconformably on the Whitehorse sandstone and the unconformity is easily seen along the contact. Immediately above this contact is a dolomite that, to some extent, resembles the Day Creek. At about the same horizon as the dolomite there occurs in places a zone of purple slaty beds about 2 feet in thickness. These purple slaty beds are well developed in some places although entirely absent only a few yards away. Just above the dolomite occurs irregularly a variable thickness of a peculiar, pinkish, conglomeratic bed, which is calcareous and probably dolomitic. In other places within the area this pinkish formation attains as much as 15 feet in thickness. The presence of unmistakable Quartermaster rocks occurring only a few feet above this dolomite, and the unconformity at its base, constitute the evidence for correlating this dolomite with the Quartermaster rather than with the Day Creek.

About a quarter of a mile south of the northwest corner of Sec. 36, T. 11 N., R. 14 W., is another place where typical Quartermaster beds occur. Near the southeast corner of this same section can be found a more or less irregular contact at the top of the Whitehorse sandstone. The beds above this contact consist of about 15 feet of gray to pinkish, hard dolomite, which looks very much like ordinary limestone. It differs greatly within short distances, and in places contains much calcite and

is conglomeratic. The writer wishes to emphasize the fact that this dolomite does not closely resemble the Day Creek dolomite as it occurs just south of Weatherford. Other buttes north of this exposure are capped by this same dolomite.

In Sec. 16, T. 11 N., R. 14 W., are two prominent beds. The lower bed is the Day Creek dolomite and the upper is an irregular bed occurring at an interval above the Day Creek dolomite. This interval ranges from 6 to 58 feet in thickness in a little more than a quarter of a mile. Here again the contact is irregular at the base of this upper bed. The pinkish conglomeratic, limy formation, which occurs above the Quartermaster dolomite in Sec. 5, T. 9 N., R. 13 W., lies above this contact. This same condition exists in the W. ½, NE. ¼, Sec. 28, T. 11 N., R. 14 W.

Near the south quarter corner of Sec. 14, T. 11 N., R. 14 W., is an outlier, composed of strata which must belong to this same irregular formation, which the writer refers to the Quartermaster. Here occur 20 feet or more of irregular sandstone and limy sandstone beds. The dips are high and the contact at the base is so irregular that there can be little doubt of an unconformity. Whitehorse sandstone, or sandstone belonging to the zone between the Day Creek and the Cloud Chief, underlies this contact. A thin dolomitic stringer, 50 or 60 feet below the contact, may represent the Day Creek. On the south side of this outlier, along the north side of Sec. 23, occurs a conglomerate bed with boulders as large as a man's fist. This conglomerate bed is only a few feet above the contact.

Just north of the east quarter corner of Sec. 35, T. 12 N., R. 13 W., is a butte capped by a dolomite bed. Here the section exposed is, from the top down:

1. A variable thickness of a pinkish, conglomeratic, dolomitic bed containing geodes.
2. About 5 feet of hard, light gray dolomite.
3. Thinly laminated, reddish sandstone, 4 feet thick, grading to purplish and slaty at the top. This formation differs locally and its contact with the underlying Whitehorse is somewhat irregular.
4. Whitehorse sandstone. The upper part of the Whitehorse here is hard and slightly limy. About 40 feet of the Whitehorse is exposed.

The writer wishes to call particular attention to the pinkish, dolomitic bed and the purplish, slaty beds exposed here, and the same type of beds occurring similarly in Sec. 5, T. 9 N., R. 13 W., which the writer calls Quartermaster.

Another line of evidence to be considered is the relation of these irregular beds to the Blaine gypsum, which has been encountered in the

dry holes drilled in this area. The well drilled in the SE. ¼, SW. ¼, Sec. 25, T. 12 N., R. 14 W., reached the top of the Blaine at an elevation of 1,050 feet above sea-level. The nearest outcrop of Day Creek dolomite is a little more than a half mile due west of this well at an elevation of 1,784 feet. A dry hole drilled near the center of Sec. 8, T. 11 N., R. 12 W., reached the top of the Blaine at 1,048 feet, while the elevation of the dolomite on the surface at this well is 1,727 feet. That is, the Blaine shows a dip of 2 feet to the southeast between these two wells, whereas, if the two dolomites were the same bed, there would be about 60 feet of southeast dip. The dolomite at this second well is irregular, with an irregular contact on the Whitehorse. Other buttes within a radius of 4 or 5 miles of this exposure are capped by this irregular dolomite, which is correlated with the Quartermaster formation.

CONCLUSION

From the evidence as set forth in this paper, the writer has drawn three main conclusions.

1. That there is a marked erosional unconformity at the base of the Quartermaster formation in this area. During the erosion period represented by the unconformity, much of the Cloud Chief gypsum, part of the Day Creek dolomite, and, in places, some of the Whitehorse sandstone, was removed, so that Quartermaster beds rest directly and unconformably on all three of these formations.

2. That the depositional basin of Day Creek and early Cloud Chief time had its greatest depth northwest of Weatherford, and not in the lowest part of the Anadarko basin.

3. That much that has been considered Day Creek dolomite is a dolomite of Quartermaster age, occurring at the base of the Quartermaster formation of this area. The dolomite that caps the Caddo County buttes, southeast of Weatherford, belongs to the Quartermaster formation,—not to the Day Creek, as heretofore believed. Such being the case, these outcrops would be unreliable for detail structural work.

DISCUSSION

Henry F. Schweer: Mr. Evans does not discuss the probability of an eastward lensing or pinching-out of the so-called "Day Creek." This eastward elimination of the Day Creek dolomite should further strengthen his interpretation of the Quartermaster problem.

By tracing the Day Creek north and east from its best exposures, northwest of the town of Colony in Sec. 9, T. 10 N., R. 14 W., it is found gradually to thin

Its importance in forming a more or less prominent ledge decreases simultaneously with the thinning of the bed and the approach of the overlying Quartermaster breccia-conglomerate, until the Day Creek is entirely absent and the Quartermaster is the prominent topographic feature.

Where positive Day Creek (so-called) is found in a vertical section with the massive Quartermaster conglomerate, the interval ranges from 4 to 55 feet. The maximum observed interval of 55 feet is significant. Intervals measured in several places showed a tendency to be consistent at 45 feet. Evans attributes the great differences in this interval to Quartermaster unconformity. Some may be due to slumping as a result of under-sapping of the finer particles in the sand.

It is noticeable that the Day Creek scarp occurs in an irregular north-south line from T. 10 N. to T. 13 N. East of this line it rapidly thins. Evans refers to an outlier in the south of Sec. 14, T. 11 N., R. 14 W., capped by this irregular Quartermaster formation. "Whitehorse sandstone, or sandstone belonging to the zone between the Day Creek and the Cloud Chief, underlies this contact" (basal Quartermaster). "A thin dolomitic stringer, fifty or sixty feet below the contact, may represent the Day Creek."

Practically all geologists who have examined this bed agree that it is Day Creek. An extension of the structural contours from the scarp to this bed at the base of the outlier indicates a stratigraphical position of equivalence, unless this is precluded by unknown structural conditions. Likewise its lithological character appears the same, but correlation of beds in this area on their manifest appearance is likely to prove misleading. However, it can be safely correlated as Day Creek by the following criteria: (1) extension of strike; (2) the fact that it occupies the same stratigraphic position,—overlain by 45 feet of typical cross-bedded Whitehorse sandstone which is in contact with the base of the Quartermaster conglomerate; (3) it demonstrates a continuance of the thinning from the west; and (4) its appearance is almost identical with that of Day Creek occurring in the scarp on the west.

In Sec. 13, T. 11 N., R. 14 W., only a mile northeast of the outlier previously discussed, there is another, though smaller, outlier, capped by the same basal Quartermaster breccia-conglomerate. Below the base of this capping stratum, 50 or 60 feet of typical Whitehorse sand is exposed. This exposure, as well as several other excellent outliers (all capped by the Quartermaster) on the east, was examined in the most minute detail. This examination failed to reveal any evidence whatever of Day Creek. There appeared to be ample section below this Quartermaster breccia-conglomerate (75 or 85 feet) to expose Day Creek if its deposition had occurred as far east as these outliers.

In Sec. 11, T. 11 N., R. 14 W., there is a small outlier of Whitehorse sandstone. Approximately 15 feet below the top there occurs an obscure gray, greenish, friable, gypsum-appearing stratum, ranging in thickness from ½ inch to 2 inches. It crumbles readily and decomposes when exposed. Assuming this to be Day Creek, it contours nicely with elevations on the Day Creek scarp a half mile west. Either this thin bed represents almost the ultimate east extension or some structural phenomenon has misplaced the Day Creek from its normal position. If the Day Creek does lense out toward the east

its normal stratigraphic position would necessarily come below that of the butte forming the Quartermaster. To what extent this has been interfered with by the Quartermaster unconformity is indeterminable.

Mr. Evans does not take into account, in his article, the presence of three distinct dolomite strata occurring near the center of Sec. 36, T. 12 N., R. 14 W. A prominent outlier occurs here, capped by dolomite which appears to be the stratigraphic equivalent of a well-laminated, hard dolomite occurring at, or near, the base of Evans' Quartermaster conglomerate. Twenty-four feet under this dolomite is another, about 6 inches in thickness, with another 23 feet below this. All three of these microscopically resemble the Day Creek, and the problem as to just which one is Day Creek (probably one of the lower two) remains unsolved. Various correlations of these strata have been made by different geologists, and a discussion of their stratigraphy which would result in a correct determination would prove interesting to many.

Another important point not discussed is the probable origin of this near-basal Quartermaster breccia-conglomerate. U. R. Laves and Hastings Moore[1] hold the view that this material may be the result of re-worked Cloud Chief gypsum during early Quartermaster time. It is evident from the angular fragments that much of the material has not been transported very great distances. Evans mentions the fact that at no place does the Cloud Chief occur immediately beneath the Quartermaster. Since no occurrence of these two formations has been found in a vertical section, the view of this conglomerate being re-worked Cloud Chief presents a strong appeal. But, if it is a dolomitic formation, as Evans says, can it be re-worked gypsum? Does this stratum deserve a name as a special phase of the Quartermaster?

Many discussions of the origin and deposition of this material have recently taken place among geologists working in the area, and its importance as an unsolved problem deserves close attention and study.

[1]Personal communication.

EXPERIMENTS RELATING TO THE RESULTS OF HORIZONTAL FAULTING[1]

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ABSTRACT

Horizontal movement along buried fault planes was simulated in the laboratory, resulting in the development of shear, thrust, and tension faults, and elongate folds. The elongation of the folds is important in connection with the origin of folds of Osage County, Oklahoma. (See previous paper by the writer.[3])

Fath[4] has explained the remarkably uniform orientation of the individual faults in the northern Mid-Continent area and their arrangement into several parallel zones as the result of horizontal movement along buried vertical fault planes. The elongation of the folds at right angles to the strike of the faults suggests a genetic relationship between them. The purpose of the following experiments on shearing was to determine whether folds would be formed by such movements, and if so, their characteristics and the conditions necessary for their formation.

DESCRIPTION OF EXPERIMENTS

Two wooden blocks were placed, in some experiments, closely side by side, and in others, with an intervening space between them, and over them was poured a mixture of vaseline and paraffin which congealed firmly to them. In most of the experiments several alternating layers of pure vaseline and a paraffin-vaseline mixture were added. The wooden blocks represented the underlying beds, the space between them, the vertical fault plane or fault zone, and the paraffin-vaseline mixture the overlying sedimentary formations. Horizontal shearing forces were applied to the wooden blocks and transmitted to the layers of paraffin

[1]Part of a doctor's thesis, University of Chicago, 1927. Manuscript received by the editor, January 4, 1928.

[2]752 South Olympia, Tulsa, Oklahoma.

[3]"Origin of the Folds of Osage County, Oklahoma," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 12, No. 5 (May, 1928), pp. 501-13.

[4]"The Origin of the Faults, Anticlines, and Buried 'Granite Ridge' of the Northern Part of the Mid-Continent Oil and Gas Field," *U. S. Geol. Survey Prof. Paper 128C.*

TABLE I

EXPERIMENTS RELATING TO THE RESULTS OF HORIZONTAL FAULTING

	Mixtures Used		Dimensions of Paraffin Blocks			Part of Paraffin Lying Over Each Wooden Block or the Intervening Space			
Experiment No.	*Layers*	*Composition***	*Thickness*	*Length*	*Width*	*Lying over Wooden Block No. 1*	*Lying over Wooden Block No. 2*	*Between Blocks Nos. 1 and 2****	*Type of Deformation in the Paraffin Block*
			cm.	cm.	cm.	cm.	cm.	cm.	
1	*a**	2:1	2.5	22	20	10	10	10	Shear along an approximately vertical fault plane
2	*a*	2:1	7	22	12.5	6.25	6.25	0	Broke away from underlying wooden block No. 1 with but slight deformation
3	*a*	2:1	1	25	15	5	5	5	Shear along an approximately vertical fault plane overlying the inside edge of wooden block No. 1
4	*c* *b* *a*	2:1 paper 2:1	1.5	33	39	13	13	13	Shear along a fault plane varying from highly inclined to nearly horizontal, strike of shear fault being essentially parallel to the direction of movement. Also folds, overthrust and normal faults with strike (or long axis) approximately at 45° to direction of movement. The normal faults have strike parallel to short axis of strain ellipsoid, while the overthrust faults and folds have strikes or axes parallel to long axis of strain ellipsoid. All deformation was confined to a comparatively small zone overlying inner edge of block No. 1, and not extending across the area between the two blocks.
5	*g* *f* *e* *d* *c* *b* *a*	2:1 1:0 2:1 1:0 2:1 1:0 2:1	2.2	18	19	9.5	9.5	0	1. Vertical shear through layer *a* 2. Horizontal shear in layer *b* 3. Rotation of layers *c* to *g* inclusive
6	*c* *b* *a*	2:1 1:0 2:1	1.5	24	24	12	12	0	Vertical shear directly above plane between blocks No. 1 and No. 2
7	*e* *d* *c* *b* *a*	2:1 1:0 2:1 1:0 2:1	2.0	22	25	12.5	12.5	0	1. Vertical shear through layer *a* 2. Horizontal shear in layer *b* 3. Rotation of layers *e*, *d*, and *f*

TABLE 1—*Continued*

	Mixtures Used		Dimensions of Paraffin Blocks			Part of Paraffin Lying Over Each Wooden Block or the Intervening Space			
Experiment No.	*Layers*	*Composition***	*Thickness*	*Length*	*Width*	*Lying over Wooden Block No. 1*	*Lying over Wooden Block No. 2*	*Between Blocks Nos. 1 and 2****	*Type of Deformation in the Paraffin Block*
8	*m*	2:1	2.0	14	50	25	25	0	1. Vertical shear through layer *a*
	l	5:1							2. Horizontal shear in layer *b*
	k	0:1							3. Rotation of layers *c* to *m* inclusive, and the development of cracks parallel to shear plane in underlying wooden blocks
	j	5:1							
	i	2:1							
	h	0:1							
	g	2:1							
	f	5:1							
	e	2:1							
	d	0:1							
	c	5:1							
	b	0:1							
	a	2:1							
9	*k*	0:1	2.0	10	60	30	30	0	1. Vertical shear through layers *a* and *c*
	j	1:0							2. Horizontal shear in layers *b* and *d*
	i	0:1							3. Development of cracks in layers *e* to *k* inclusive, parallel to shear plane in underlying wooden blocks
	h	1:0							
	g	0:1							
	f	1:0							
	e	0:1							
	d	1:0							
	c	0:1							
	b	1:0							
	a	0:1							
10	*c*	2:1	3.0	22	22	11	11	0	1. Vertical shear through layer *a*
	b	1:0							2. Horizontal shear in layer *b*
	a	2:1							3. Rotation of layer *c*
	Note: Layers *a* and *b* respectively were only 0.4 and 0.2 cm. thick								

*The lettering of the layers begins with the bottom layer of the paraffin-vaseline mixture, as *a*.
**Under composition, the parts of vaseline are given first, then the corresponding parts of paraffin, thus, 2:1 indicates that the mixture contains two parts of vaseline and one part of paraffin.
***The distance between the wooden blocks, No. 1 and No. 2, represents the width of the shear zone.

and vaseline, which resulted in the formation of folds, both normal and overthrust faults, shear along vertical and horizontal planes, and rotation of the upper blocks. (Table I.)

Extension of vertical shear plane.—In experiments 1, 2, and 3 the blocks were of homogeneous composition. In experiment 2, the paraffin-vaseline mixture separated from the wooden blocks, while in the other

two experiments a vertical shear plane was formed in the paraffin-vaseline mixture immediately above the zone between the two wooden blocks.

Rotation of upper beds.—In the other shearing experiments, with the exception of 4, alternating layers of pure vaseline and a paraffin-vaseline mixture were molded into blocks and subjected to shearing forces. In experiments 5, 7, 8, and 10 vertical shear extended through the lowest layer, which was relatively resistant; and horizontal shear occurred in the second layer, which offered but slight resistance to deformation. The horizontal shear in the second layer resulted in the rotation of all the overlying layers.

Complex shearing.—In experiment 9, boards were attached vertically to the ends of the underlying rigid blocks and formed the ends of the mold into which the paraffin and vaseline were poured. These vertical wooden boards prevented the rotation of the paraffin-vaseline blocks when the shearing forces were applied. Both vertical shear, in the relatively resistant beds, and horizontal shear, in the weaker beds, occurred in the lower portion of the block and, instead of rotation in the upper portion of the block, vertical cracks were developed parallel to, but not directly over, the underlying original shear zone. Similar cracks were developed in experiment 8.

Development of folds and faults.—Folds and thrust and normal faults were produced in experiment 4, in which paper was used as a middle layer (Fig. 1). Shear occurred along a fault plane varying from a highly inclined to an essentially horizontal position, the strike of the new shear plane being almost parallel to that of the underlying shear zone. The long axes of the folds and strike of the thrust faults were parallel to the long axis of the strain ellipsoid, while the strike of the normal faults was parallel to the short axis of the strain ellipsoid. The strike of the faults and the long axes of the folds formed an angle of 45° to the strike of the underlying shear zone. The folds developed were three to five times as long as they were wide, in spite of the fact that they were truncated by normal faults.

GEOLOGICAL SIGNIFICANCE

Shearing.—The experiments suggest that shearing movements along buried fault planes may result in several distinct types of deformation at the surface, depending, in part at least, upon the character of the rocks,—whether they are essentially uniform or a series of alternating competent and incompetent sedimentary beds. In the former type of beds, conditions are apparently favorable for the extension of the old

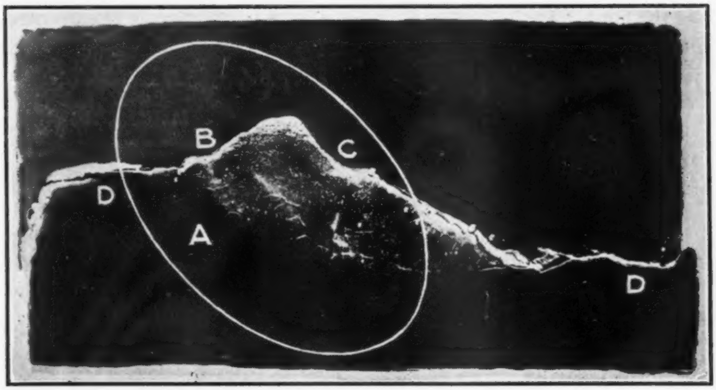

FIG. 1.—Photograph of top of the paraffin block used in experiment 4 on shearing. That portion of the block in the upper part of the figure moved relatively to the left, as shown by the offset in the edges of the block. The white ellipse represents the strain ellipsoid. Folds are developed at *A*, thrust faults at *B*, tension faults at *C*, and shear faults at *D*. The photograph fails to show the true length of the folds.

fault planes vertically through the overlying beds, the old and new faults lying in a single plane. But experiment 9 suggests that where the beds are of varying resistance, the upward extension of faults by renewed movement along old fault planes may result in both vertical and horizontal faults. The vertical fault planes occur in the resistant formations connected by horizontal fault planes in the weaker formations, the vertical fault planes being parallel to (but not necessarily immediately overlying) the old vertical faults along which movement first occurred.

Rotational stress.—In most of the shearing experiments involving beds of varying resistance, horizontal faulting developed, which caused the rotation of the overlying beds. But in the earth's crust, rotation of the strata would be prevented by the presence of the same or other strata, although rotational stresses might well develop; consequently, one might apply the principles of rotational stress to a series of alternating competent and incompetent beds immediately overlying a shear zone. This inference is further strengthened by experiment 4 in which folds and normal and thrust faults having the orientation characteristic of rotational deformation were developed just above the shear plane. (See Figure I and Table I for experiment 4.) One may infer that both folds and normal faults will develop at the same time by horizontal shearing along an underlying fault plane, and that the strike

of the faults and the axes of the folds will be perpendicular to each other and will form an angle of 45° to the underlying shear plane. While the faults and folds in Osage County, Oklahoma, conform to the foregoing relations, it should be noticed that the ratio of the length to the width of the folds developed in the experiments is much greater than in the Osage folds, as has been mentioned in a previous article.[1]

CONCLUSION

Horizontal movement along buried faults may result in the development of shear faults or folds and tension and thrust faults. The folds are greatly elongated and apparently are produced only when the underlying beds are of varying competency.

[1] "Origin of the Folds of Osage County, Oklahoma," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 12, No. 5 (May, 1928), pp. 501-13.

VENTURA AVENUE OIL FIELD, VENTURA COUNTY CALIFORNIA[1]

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ABSTRACT

The Ventura Avenue oil field is located in Ventura County, California, about 2½ miles north of the city of Ventura, in the Ventura River valley. This field has the reputation of being the most difficult field in California in which to complete a deep well. The topography of the field is very rough, embracing elevations from 100 to 1,100 feet. The Ventura anticline is 16 miles long with Ventura Avenue field at the center. The anticline plunges in both directions from the center of the field and is characterized by steep dips on the flanks, which range from 30° to 60°. Production comes from the Pico formation, of lower Pliocene age. The field has six oil zones, but practically all production comes from the deepest zone, the Lloyd, which claims the deepest commercial oil producer in the world, in the Associated Oil Company's Lloyd No. 102. It was drilled to a depth of 7,210 feet, and had an initial production of 3,600 barrels per day. The Lloyd zone has a known thickness of 2,600 feet, with the bottom of the zone as yet not found. The Ventura Avenue field has at present (February, 1928) a production of 57,000 barrels per day of 29° to 30° gravity oil, from 113 wells. The field has produced, since its discovery in 1915, up to January 1, 1928, approximately 44 million barrels of oil and more than 130 billion cubic feet of gas, yielding approximately one gallon of gasoline per thousand cubic feet of gas, and should ultimately produce 250 million barrels of oil and 600 billion cubic feet of gas.

INTRODUCTION AND LOCATION

The Ventura Avenue oil field has only recently come into prominence as an oil-producing area, although the field has been producing oil for more than ten years. The new general interest in this field is due to the greatly increased production in the past two years and the extreme depth and great thickness of the oil zones.

The Ventura Avenue oil field is situated on both sides of Ventura Avenue, the main highway leading from the city of Ventura to the Ojai valley. The field lies about 2½ miles north of the city, in the Ventura River valley. This field, which has been so slow in development, now promises to be one of California's great oil and gas producers. It has been the privilege of the writer to watch it develop, from a field of six wells, producing 345 barrels per day in August, 1921, to a production of

[1]Read before the Association at the San Francisco meeting, March 23, 1928. Manuscript received by the editor, April 4, 1928.

[2]Resident geologist, Ventura division, Associated Oil Company.

60,000 barrels of oil and 220 million cubic feet of gas per day, from 72 wells in November, 1926. Figure 1 shows a view of Ventura Avenue oil field taken in 1928, looking east across Ventura River from the Shell Company's Taylor lease to the Associated Oil Company's Lloyd lease. Figure 2 shows the location of Ventura Avenue and Rincon oil fields on the Ventura anticline.

To one who has not been associated with the operations in the Ventura Avenue field, it is difficult to realize the obstacles that nature has set in the path of development of this field. The hard, shifting, and squeezing formations must be penetrated to great depths, in the face of tremendous gas pressures, to reach the best producing zone. As a result of these difficulties, the Ventura Avenue field has the reputation of being the most difficult territory in California in which to complete a well. Nor is the task completed, for the bottom of the producing sands has not yet been reached.

TOPOGRAPHY

Although the Ventura anticline is situated in an area of relatively recent physiographic development, the topography gives but slight indication of the presence of a fold of such magnitude. There is no evidence of an anticlinal ridge nor is there any pronounced line of uplift along the axis of the structure. The anticline is dissected at the surface by eleven stream courses varying in magnitude and direction, the most conspicuous being the canyon of Ventura River. Near the dome of the anticline, along Ventura River, the major streams cut across it at right angles without special regard to the geologic structure. However, streams that cut the anticline farther down the plunge, on either side of the dome, are influenced by the folding, and swing in a curve around the nose of the structure.

The highest elevation in the present productive area is about 1,150 feet above sea-level, although extension of the field to the east and west may overlap elevations in excess of 1,500 feet. The lowest elevation in the field is about 100 feet, where Ventura River cuts, at right angles, through the anticline.

There are about 300 acres of flat land in the field in the Ventura River valley, where the anticline is structurally the highest. The other 900 acres of practically proven acreage lie in the hills. This condition has necessitated cutting roads and rig grades out of the steep hillsides. The construction program has required the moving of nearly 2,000,000 cubic yards of sand, shale, conglomerate, and hard sandstone for roads,

FIG. 1.—View of Ventura Avenue oil field taken in January, 1928, looking east across Ventura River from the Shell Company's Taylor lease to the Associated Oil Company's Lloyd lease.

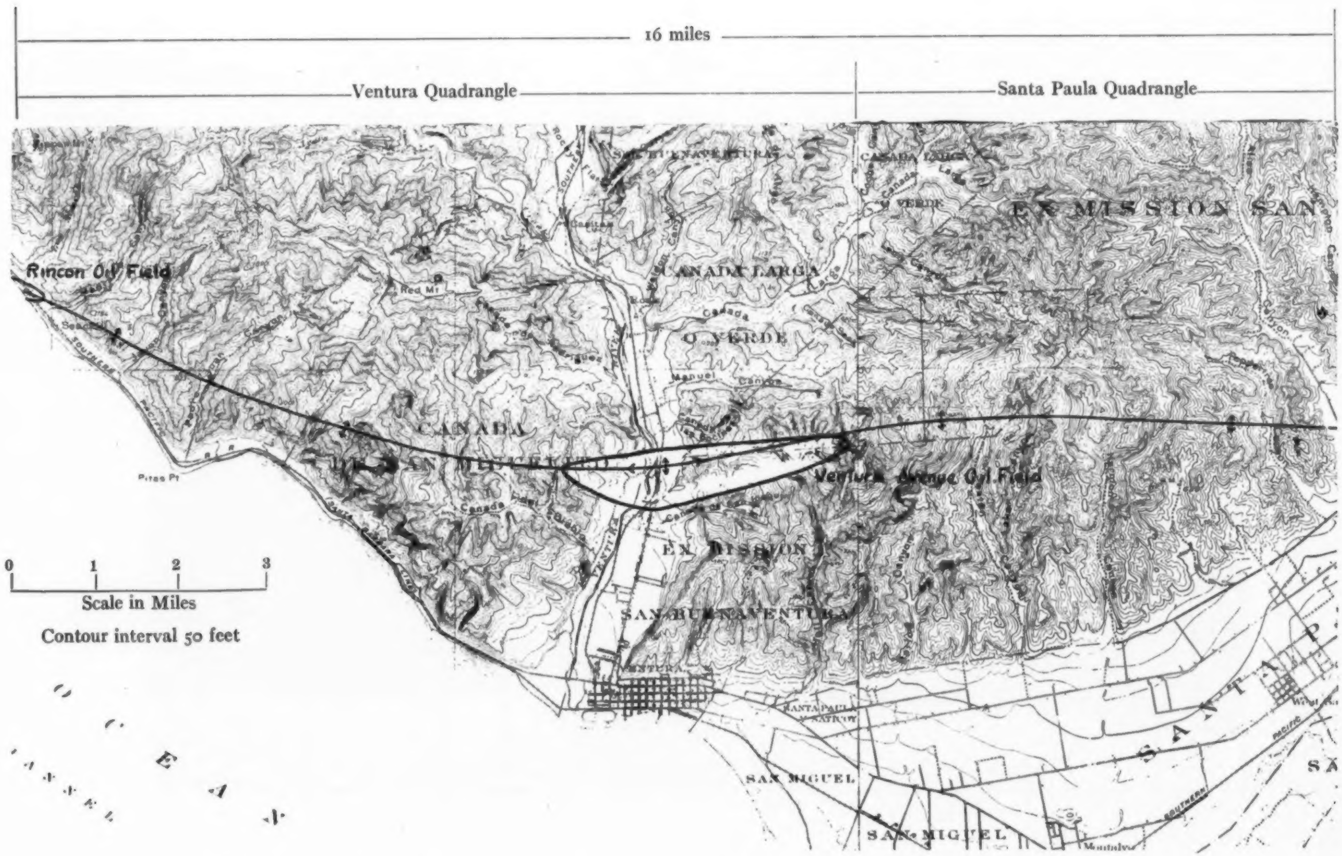

FIG. 2.—Map showing position of Ventura Avenue and Rincon oil fields along the Ventura anticline. (U. S. Geol. Survey.)

rig grades, tank grades and sump holes. One rig grade in particular required the excavation of a 90-foot cut and the moving of some 35,000 cubic yards of material.

STRUCTURAL GEOLOGY

The Ventura Avenue field is located on the structurally highest part, and at about the center of the large and perfectly closed Ventura anticline, a sharp and well-defined fold, approximately 16 miles long and extending generally east and west. It is traceable from the center of the field about 8 miles east, to a point where it plunges into the Santa Clara valley, and about 8 miles west, where it enters the Pacific Ocean. Figure 3 shows a view of Ventura anticline 4 miles west of Ventura River.

Figure 4 shows a view looking east into Hall Canyon and gives an idea of the many surface outcrops which are found along the structure.

The structure is characterized by steep dips which range from 30 degrees to 60 degrees on the flanks of the anticline. East of the center of the field, the anticline plunges on an average of about 3 degrees to the east for 1½ miles. Here there is a structural terrace and thence eastward it has a plunge in the same direction of about 8 degrees. West of the center of the field it has a 3° plunge westward for about 3 miles. Here it flattens for some distance, but no exact low point can be determined. However, at some point within this uncertain area, there is a low point, for where the anticline enters the ocean, or at the new Rincon oil field, the structure is again rising.

Although the anticline is practically symmetrical, in the center of the field it is not constantly so. For example, about 1½ miles east of the center of the field in Hall Canyon, in the vicinity of the Associated Oil Company's Lloyd No. 101, the axial plane has a pronounced dip to the south, amounting to 600 feet or more in 5,000 feet of depth. Beyond this point, to the east, the structure seems to become gradually symmetrical again. West of the center of the field the axial plane dips to the north.

The subsurface structure as shown by the subsurface contour map on the base of the Gosnell shale (Fig. 5), shows a nearly perfect anticlinal structure very similar to the one mapped by the surface outcrops. The plunge in both directions from the apex in Ventura River and the structural terrace in Hall Canyon, is again noticed in the subsurface map. The steeper dips on the north side of the axis east of the field which give the axial plane a hade to the south, and the reverse situation west of the center of the field, are also illustrated by the subsurface contour map. The present proved area, between the Shell Company's Taylor No. 16

FIG. 3.—View of Ventura anticline 4 miles west of Ventura River.

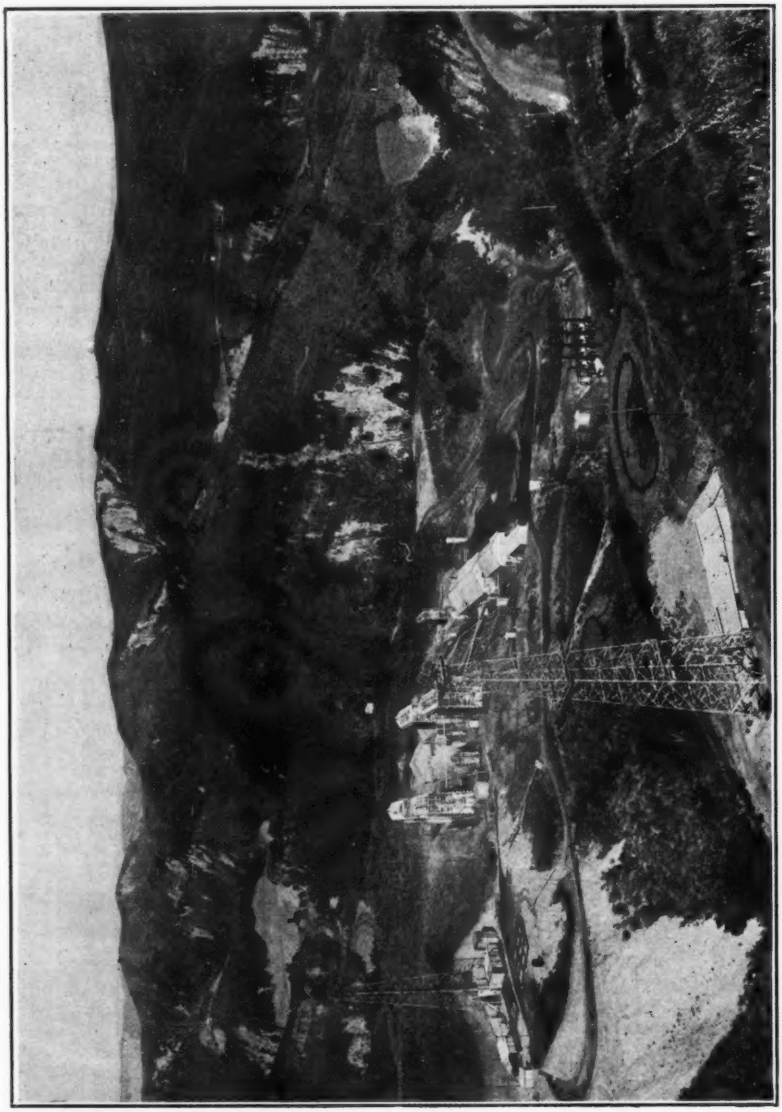

FIG. 4.—View looking east into Hall Canyon, showing many surface outcrops which are common along Ventura River.

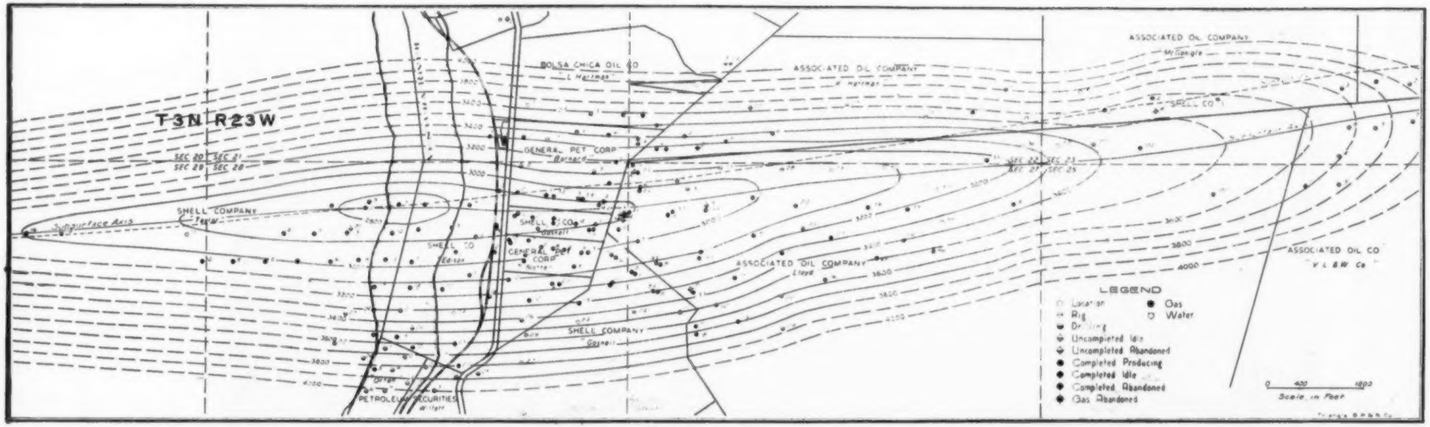

FIG. 5.—Subsurface map of Ventura Avenue oil field, showing structure at base of Gosnell shale, below sea-level. Contour interval, 1,000 feet.

and the Associated Oil Company's Dabney Lloyd No. 1, shows closure of about 400 feet. The rest of the structure both east and west will show a closure of more than 1,000 feet, though not all of this will prove to be commercially productive.

The large drainage area of this structure is a contributing factor to the amount of oil found in the Ventura anticline. As the anticline has only one major dome, from Padre Juan Canyon on the west, to Aliso Canyon on the east, this great amount of oil is in one reservoir. The drainage area extends about 1 mile north of the axis and at least 3 miles south of the axis for a width of 14 miles. The area on the north is cut off by a syncline and a fault. Though there may be a still greater area on the south side, this cannot be determined because of the alluvial covering of the Santa Clara River valley and the Pacific Ocean.

FORMATION AND OIL ZONES

All of the present drilling and production in the Ventura Avenue field is in the Pico formation (lower Pliocene) of the Fernando group (Fig. 6). In the Ventura region the Fernando is composed of the Saugus and Pico formations which have a total thickness in excess of 15,000 feet in the vicinity of the Ventura anticline. The strata penetrated consist of fine- to coarse-grained sand varying from loose-running sands to extremely hard sand, sandy shale of varying hardness, and a lesser amount of blue, gray, and brown shale, much of which contains an abundance of *Foraminifera*. The predominating sediment found in the lower oil zones, however, is a medium to fine sand that grades in many places into a very fine or "flour" sand.

Six different producing zones in the Ventura Avenue field are known, but at only one point (the Gosnell shale zone) is there a definite marker between them. The difference in the quantity and quality of the production and the areal extent of the zones are the only criteria for differentiation between them. Even at the Gosnell shale zone it is not everywhere possible to differentiate because many parts of this zone are sandy. An approximate correlation may be worked out from a study of the *Foraminifera*.

The first evidence of petroleum to be found is a gas zone on the crest of the structure and extending from a depth of 300 feet to 1,600 feet in fairly loose sands and sandy shales. This zone, although of no economic value at present, was once capable of supporting small commercial gas wells producing possibly two barrels a day of 56° Bé. gravity oil. It is now flooded and gives nothing more than about 1,000 barrels per day of

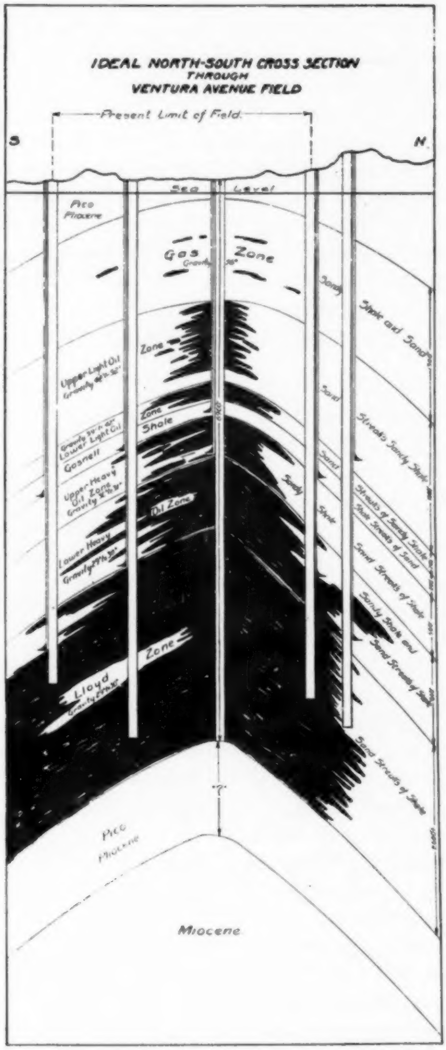

FIG. 6.—Oil zones in Ventura Avenue field. Depths shown in feet.

salt water. This zone is of historic interest, however, on account of the fact that here the first clew to the oil deposits lying beneath was discovered.

After penetrating the gas zone, the upper Light-Oil zone is gradually encountered, but with no marked change in lithology from the sands and sandy shales of the gas zone. This zone was originally capable of producing approximately 150 barrels of 48° to 52° Bé. gravity oil per well, with as much as 1,500 barrels of salt water and about 200,000 cubic feet of gas. The zone extends from 1,600 feet to 2,600 feet in depth, although the best oil production occurs from 1,900 to 2,500 feet. The upper Light-Oil zone is now flooded with water and very little oil is obtained from it. There are three wells in this zone which at present (February, 1928) produce an average of about 13 barrels of 48° to 52° Bé. gravity oil, 10,000 cubic feet of gas and 270 barrels of water per day.

Below this zone, and just above the Gosnell shale, is found the lower Light-Oil zone. It consists of about 200 feet of loosely consolidated sands and sandy shales, originally capable of producing about 50 barrels per well, of 39° to 42° Bé. gravity oil and 100 barrels of water per day. This zone is also no longer of economical importance as there is no production from it at present.

The Gosnell shale horizon, which consists of a variable shale body reaching a maximum of 200 feet in thickness, streaked with sandy shale and sands, is found between the lower Light-Oil zone and the upper Heavy-Oil zone at a depth of about 3,000 feet in the center of the field. This horizon is the best marker in the field, but sometimes becomes so sandy that it cannot be distinguished from the other zones, thus rendering correlation difficult.

The upper Heavy-Oil zone occurs below the Gosnell shale. It consists of 500 feet of sands and sandy shales, streaked with shale. This zone originally gave rise to wells not exceeding 150 barrels of 30° to 31° Bé. gravity oil, 1,000,000 cubic feet of gas, and from 30 to 60 barrels of salt water per day. The upper Heavy-Oil zone has probably been damaged to some extent by infiltrating water, although an effort has been made to protect it by cementing a string of casing above and below, and mudding the zone as it was penetrated. At present there is no production from this zone, but at some future time, when oil is not so plentiful as it is to-day, it will probably pay to drill wells for production from this zone along the top of the anticline.

The lower Heavy-Oil zone, found immediately below the upper Heavy-Oil zone and extending for 800 feet with a similar lithological

character, is capable of supplying considerably larger wells having initial productions as high as 1,900 barrels of 29° to 30° Bé. gravity oil and from 2,000,000 to 4,000,000 cubic feet of gas per day. It is free from water on top of the structure, but edge water, especially in the upper part of the zone, is encroaching on the flanks of the structure.

The deepest and richest of the zones has been named the Lloyd zone by the writer.[1] It has been so designated because discovered in the Associated Oil Company's Lloyd 9A. It comprises all of the oil zone below a point 1,300 feet below the base of the Gosnell shale, and to the present explored depth of 3,920 feet below the Gosnell shale, giving it a known thickness of 2,620 feet. Lithologically it is similar to the Heavy-Oil zones, but is characterized by its greatly increased productivity over any of the other zones previously mentioned, and by its considerably greater areal extent. However, in some of the wells now drilling on the edge of the field, edge water is noticed in the top part of the Lloyd zone.

The Lloyd zone has supplied wells with an initial production of as high as 5,700 barrels per day of clean oil, and gas wells on the top of the structure have shown initial gas production of 45,000,000 cubic feet per day and initial flow pressures as high as 1,100 pounds per square inch. This zone is entirely free from water, except as previously mentioned on the edge of the field.

Further drilling will add further proven thickness to the Lloyd zone and to the Pico formation below which probably productive Miocene formations lie. If oil sands are found in the Miocene formations, as is the case in three of the Los Angeles basin oil fields, substantial production may be expected from this source.

The Modelo shale of Miocene age is considered by most geologists as the generating series for the oil in the Ventura field. This oil is thought to have originated in the organic Modelo shale and migrated into the overlying Pico formation.

During the process of upward migration, the heavier constituents were left in the lower strata while the lighter hydrocarbons migrated into higher members. Another theory advanced by a few local geologists is that the oil originated in organic shales within the Pico formation and accumulated in the adjacent or overlying sands, the lighter constituents accumulating in the upper sands of the structure. It may be that both were contributing factors in the accumulation of the oil and gas in the

[1] F. W. Hertel, "Ventura is One of California's Greatest Oil Fields," *Oil Weekly*, Vol. 44, No. 11, March 4, 1927, pp. 47 *et seq.*

Ventura anticline. However, the lack of surface exposures of Pliocene organic shale renders the latter explanation less tenable.

MECHANICAL PROBLEMS

During the early development of the field, cable tools were used exclusively, but gradually, in the later years, the rotary method replaced the cable tools, until at present rotary tools are used exclusively, except for occasional re-drilling. The rotary was found superior in handling the tremendous gas pressures encountered in drilling. It also enables the setting of larger strings of casing at greater depth, and results in more satisfactory coring of formations, therefore giving better data on the location of the various gas, oil, water, and shale strata.

The casing program used at present employs a conductor string of 18⅝-inch or 20-inch casing to a depth of about 700 feet, 13⅜-inch or 11¾-inch casing is then set in the Gosnell shale, for primary shut-off, ranging in depth from 2,900 to 4,500 feet. The secondary shut-off is made with either 10¾-inch or 9-inch or 8⅝-inch casing, at depths ranging from 600 to 2,000 feet below the primary shut-off, depending on the position of the well on the structure. Due to edge-water encroachment in the upper sands it is necessary to set secondary water strings on the edge of the field, considerably lower, which in some wells necessitates setting 8⅝-inch casing below 6,000 feet. The wells are then finished with either 5¾-inch or 6⅝-inch casing as an oil string, the secondary cementing being reinforced in some wells by a combination cement job. Oil strings containing more than 2,500 feet of perforated pipe have been run, and clean wells brought in.

The depths at which casing of different sizes has been successfully landed in the Ventura field might prove interesting, as some of them are probably world records.

TABLE I

Outside Diameter in Inches	*Weight Pounds per Feet*	*Depth in Feet*	*Total Weight (Tons)*	*Company*	*Well Number*	
13⅜	61	4,321	131.8	Shell Co.	Gosnell	25
11¾	54	4,475	120.8	Petrol. Sec. Co.	Orton	6
10¾	45	3,930	88.4	Assoc. Oil Co.	Lloyd	43
9	45	5,090	114.5	Assoc. Oil Co.	Lloyd	102
8⅝	36	6,055	109.0	Petrol. Sec. Co.	Willett	3
6⅝	26	6,505	84.6	Assoc. Oil Co.	Lloyd E	39
5¾	20	7,095	71.0	Shell Co.	Edison	19

At present these deep wells take from four to six months to drill to completion, the average daily footage ranging from 30 to 50 feet. Faster

time, of course, is made in the upper part of the hole, where the formation seems to be a little softer. Here disc bits are used to good advantage, and an average of 100 feet per day can be maintained for the first 3,500 feet.

When the oil zones are reached, drilling is retarded by harder formations and hard rock bits may be required. Also, squeezing and heaving formations are encountered that, in spite of the utmost care, cause the freezing of numerous strings of drill pipe, most of which may be loosened by spotting or circulating oil. However, some cannot be loosened and entail long and tedious fishing or side-tracking jobs. The handling of the heavy gas pressures is probably the most difficult, baffling, and treacherous feature to combat in the deeper drilling. This considerably retards the work, as in many wells it has been necessary to stay in the hole for several days before the gas has been mudded off and killed so that a "round trip" to put on a sharp bit could be made.

In one well drilled recently, it was the regular practice to make a "round trip" only every two days. Time was taken up by mudding-off the gas after getting back in the hole, before drilling could be resumed. The drilling then consumed from 8 to 14 hours, and the remaining time was taken up in mudding off the hole until it was safe to make the quick "round trip." Gas pressures as high as 1,300 pounds per square inch have been recorded during the drilling.

Due to the sandy nature of the formations drilled through, and lack of shale strata in the wells from which to make mud fluid, it is necessary to haul dry clay from a suitable pit, in the upper Pico formation, about a mile away. This clay is hauled in dump trucks to mud mixers on the various leases. Here the clay is mixed into a mud fluid, weighing from 80 to 90 pounds per cubic foot, and then pumped to the wells for use. This mud fluid, though very satisfactory as a drilling mud, and for mudding-off the running strata, may not be of sufficient weight to hold down the heavy gas pressures encountered. Therefore, heavy mineral compounds, such as barite (barium sulphate) and hematite (iron oxide), both in powdered form, are added to the mud fluid to give it additional weight. By adding either of these heavy mineral compounds to the mud, a fluid weighing 105 pounds per cubic foot can be secured which is still fluid enough to be handled by the pumps. In a well recently drilled in the field, more than 1,000 tons of hematite were necessary before the well was completed. In spite of the use of this extra heavy mud, the use of blow-out preventers and other precautions, blow-outs occur now and

then and many wells are brought in "barefoot" as there is not time to run in oil strings.

HISTORY OF DEVELOPMENT

The drilling of a water well in 1885, on the property of A. D. Barnard, now the General Petroleum Corporation's Barnard lease, brought about evidence relative to the possibilities of oil in this locality. This well was drilled to a depth between 200 and 300 feet, where brackish water, a small amount of gas, and scum of light-gravity oil were encountered. This was a surprise, as oil and gas at that time were not expected anywhere except around the great seeps in other parts of the county. Mr. Barnard erected a sign near the well with the following inscription, "Oil, Gas, and Salt Here." This was a source of amusement to passers-by for some time, none of them realizing that some day this very spot would be surrounded by oil derricks.

In 1898 R. B. Lloyd and E. A. Rasor, who had had some geological experience in the Fullerton field, mapped the Ventura anticline. In spite of Lloyd and Rasor's favorable report on the field, no development work was commenced. Some time before this, two men by the name of Carpenter and Steinbeck bought the oil rights to all the property in the Rancho Ex-Mission San Buena Ventura, except that of tract "R," which later became the Lloyd ranch. Tract "R" was discarded as valueless by these men, since the anticlinal theory of oil accumulation had few followers at that time, and since everyone was interested in the faulted structures where the oil seepages occurred.

In 1902 the new Weldon Oil Company drilled its Hartman No. 1 in Section 22, T. 3 N., R. 23 W., S. B. & M. This well was drilled near the axis of the anticline a short distance east of the dome but reached a depth of only 750 feet. Some gas was encountered, but mechanical difficulties caused abandonment of the well.

Later on, in 1903, interest was again directed to gas seepages coming up in the Ventura River bed near the dome of the structure, which led to the Ventura County Power Company's drilling a well in Section 28, T. 3 N., R. 23 W., to a depth of 400 feet and the discovery of a shallow gas zone. Nine wells in all were drilled shortly after this to depths ranging from 400 to 800 feet, for the purpose of supplying gas for domestic use in Ventura and Santa Paula. In spite of the fact that these wells produced from 10,000 to 15,000 cubic feet of gas per day and a barrel or two of 56° Bé. gravity oil, the large amount of water in the wells, and the difficulty in drilling them in the river bed with the prim-

itive cable-tool rigs, caused the abandonment of the enterprise, and Ventura returned to the use of artificial gas. The casing of some of these old gas wells may still be found in the Ventura River bed, and on top of the water in all of them is found a small amount of high-gravity oil. In spite of the actual production of gas from the structure, it was with difficulty that any capital could be secured for oil prospecting in the field. However, in 1913 Ralph B. Lloyd was able to interest J. B. Dabney and E. J. Miley of the State Consolidated Oil Company.

In January, 1914, Lloyd No. 1 was spudded in by the State Consolidated Oil Company. After many difficulties, this well was drilled into the upper Light-Oil zone to a depth of 2,558 feet, at which depth, in July, 1915, the well blew out, wrecking the derrick and spraying gas, oil, and water. Though this ruined the well as a producer, it definitely established the presence of oil in the Ventura anticline.

About the same time that the State Consolidated Oil Company commenced on the Lloyd lease, Lloyd and Dabney commenced drilling on the Taylor lease, west of Ventura River. This partnership, using the facilities available at that time, drilled three wells, but none of them below 1,000 feet, due to inability to cope with the heavy gas pressures. After their unsuccessful efforts, Lloyd and Dabney transferred their leases to the Shell Company of California in June, 1916.

Later, other wells were drilled into this light zone, some of which produced for a time. One produced as much as 100 barrels per day. Great difficulties were experienced in attempting to produce from this zone, due to the lack of a suitable clay, or shale, in which to cement a water string to shut off the large flow of upper water. It also was found that water occurred within the oil zone, which soon became flooded. Excessive gas pressures in this zone, also, made drilling very hazardous, as several severe gas blow-outs occurred during the drilling. The wells blew out, destroying the rig and subsequently forming craters 75 to 100 feet in diameter, full of oil, mud, and water, with the gas continuously bubbling through them. One well being shut in, broke out at the surface 400 or 500 feet from the well, where a geyser of water, mud, oil, and gas shot into the air 8 or 10 feet, until again released at the well.

With improved drilling methods and a better understanding of local conditions, an important step forward was made when the Shell Company was able to drill its Gosnell No. 1 through the Gosnell shale into the upper Heavy-Oil zone to a depth of 3,495 feet in April, 1919, and gave the field a 135-barrel producer. But this zone contained water and, as the wells were costly, they were not great money-makers. There-

fore, after drilling a few wells to this zone with no better success than that of the first venture, the Shell Company prospected further. This time, after cementing off the water and oil in the upper Heavy-Oil zone, the Shell Company drilled into the top of the lower Heavy-Oil zone, and in November, 1921, brought in a clean well in Taylor No. 3 at a depth of 3,737 feet, with an initial production of 400 barrels per day. This was followed by greater successes through the deeper penetration of the lower zone. When, in March, 1922, the Shell Company's Gosnell No. 3 was brought in, at 3,855 feet, it was a 939-barrel producer. The Associated Oil Company, which had taken over the State Consolidated Oil Company's property in June, 1920, brought in Lloyd No. 5 in October, 1922, at 4,051 feet, a 1,900-barrel well, which had penetrated the lower Heavy-Oil zone a little more than 300 feet. Several wells were drilled into this oil zone and a few satisfactory wells were completed and the lower Heavy-Oil zone extended to a thickness of 800 feet.

In spite of the satisfactory producers in the lower Heavy-Oil zone the operators in the Ventura field were not satisfied, and in January, 1925, the Associated Oil Company brought in Lloyd No. 9A at 5,150 feet, producing from 700 feet of the lower Heavy-Oil zone, and from 300 feet of the Lloyd zone. This well made 4,639 barrels of 30° Bé. gravity oil, cutting less than 1 per cent water and with 15,000,000 cubic feet of gas. This was more than double the production of any previous well in the field. Three years after completion, this well was still flowing clean oil at the rate of 250 barrels per day, having produced over 1,000,000 barrels of oil in the first 22 months of its existence.

It has been followed by many producers from the Lloyd zone, which has now been prospected to a depth of 2,600 feet, and the bottom not yet reached. To date this zone has given the field 108 producers varying in production from 1,000 to 5,700 barrels and ranging in depth from 4,700 feet to 7,100 feet. The Lloyd zone now claims the deepest commercial oil producer in the world in Lloyd No. 102 of the Associated Oil Company at a depth of 7,210 feet, with an initial production of 3,600 barrels per day.

Besides the deeper penetration of the Lloyd zone, another important development was the bringing in of Lloyd No. 101 in Hall Canyon, by the Associated Oil Company, in March, 1926. This well was a 1,600-barrel producer at 5,392 feet and extended the field a mile beyond the limits of production at that time. With the extension of the field to the west by the Shell Company, with its Taylor No. 16, and the Associated Oil Company, with its Dabney-Lloyd No. 1, on the east, the field at

present shows an actual proved area 3 miles long and 3/4 mile wide at the widest point and bids fair to increase these figures considerably.

The leases in the Ventura Avenue field have been held in large blocks by the Associated Oil Company, Bolsa Chica Oil Company, General Petroleum, Petroleum Securities Company, and Shell Company. Until 1925 the Associated Oil Company, General Petroleum Corporation, and the Shell Company were the only operators in the field. Since then the Bolsa Chica Oil Company and Petroleum Securities Company have taken leases on the flanks of the structure. At that time these latter holdings seemed doubtful of production, but they are now rewarding these operators in good measure for their efforts. Beyond the limits of production down the plunge of the anticline on the east in Sexton Canyon, four miles from the center of the field, the Milham Exploration Company drilled a well to 7,092 feet without obtaining any important showings. This has apparently limited the field on the east, although it is possible still deeper drilling might uncover productive sands. On the west the Associated Oil Company drilled its Taylor No. 1-A in Diablo Canyon, 2½ miles from the center of the field, to a depth of 5,215 feet with no important showings. Deeper drilling, however, might prove the structure productive at this point. On the north, G. J. Magenheimer drilled a well to 7,320 feet with no commercial production secured. This would seem to limit the field at this point. However, the Star Petroleum Company is drilling a well east of the Magenheimer well which may extend the field in that direction. On the south flank of the field, south of the Petroleum Securities Company leases, the M. K. T. Oil Company is drilling a well which may extend the field down the south flank.

PRESENT STATUS OF FIELD

The field at present (February, 1928), is producing from 113 wells approximately 57,000 barrels of 29° gravity to 31° gravity oil, 213 million cubic feet of gas, and 4,500 barrels of water per day. This shows a daily average per well of 504 barrels of oil and 1,885,000 cubic feet of gas. Of the present 113 producing wells in the field 102 are flowing and 11 pumping. There are 52 wells 6,000 feet or more in depth, 18 are 6,500 feet or deeper, and 5 wells more than 7,000 feet. The average depth of the 113 wells is 5,650 feet.

Since November, 1926, when the peak of 60,000 barrels per day was reached, the production in the field has held between 50,000 and 60,000 barrels per day, except for the months of May to August, 1927, when the field was shut in 33⅓ per cent to curtail over-production (Fig 7).

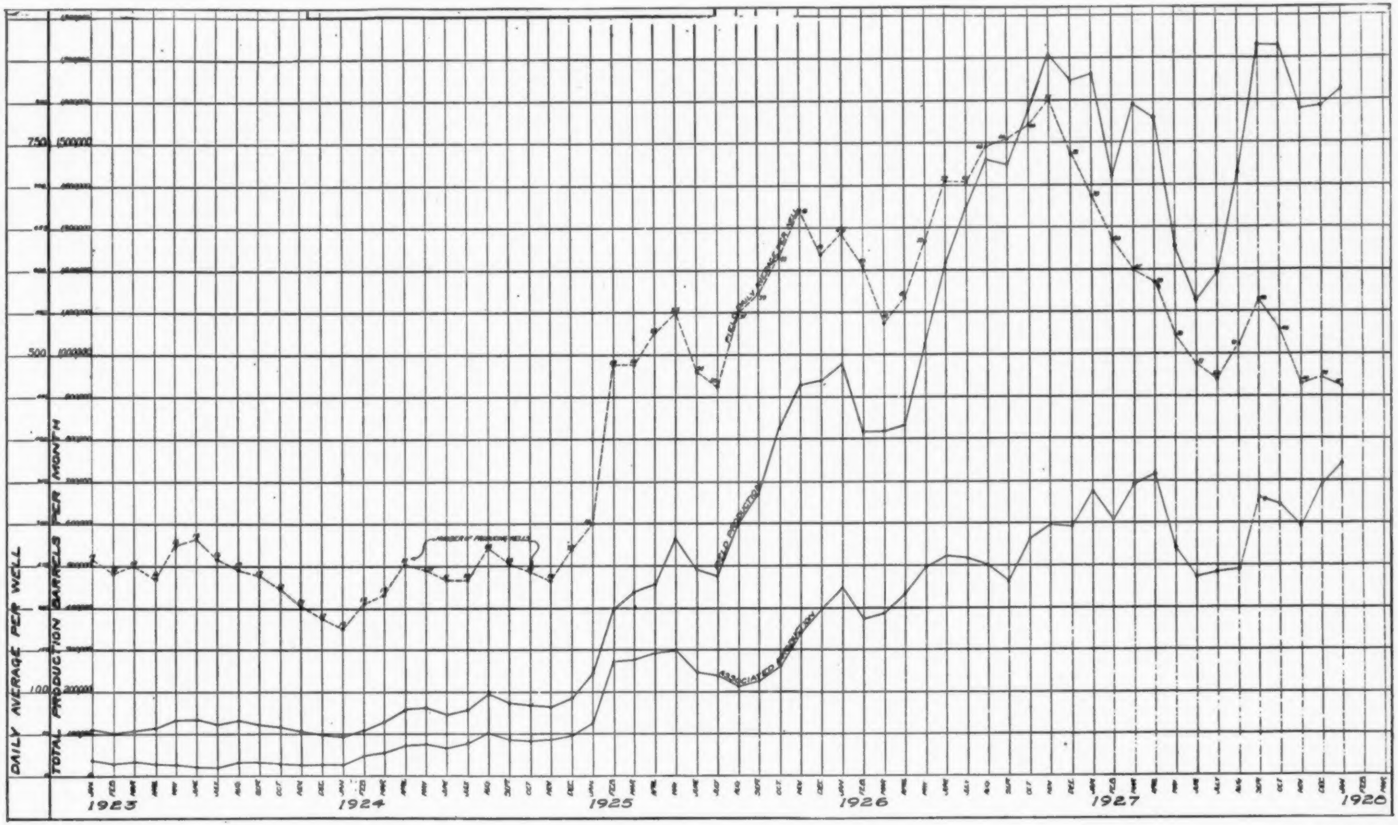

FIG. 7.—Chart showing monthly oil-production curve in Ventura Avenue field.

Production per acre is at present rather difficult to estimate, because the field has much proved area as yet undrilled. However, the General Petroleum Corporation's 12½-acre Notten lease gives an idea of the productiveness of the sands in the Ventura Avenue field. This lease is situated near the center of the field, which is practically drilled except for zones below those already discovered. At present it shows a recovery of 330,000 barrels per acre and should ultimately produce 375,000 barrels per acre. The field as a whole, with the present discovered zones, cannot be expected to run as high as the Notten lease as there are some parts that are not nearly so productive, but the field should give an ultimate production of more than 200,000 barrels per acre.

An analysis of Ventura Avenue crude oil by Egloff and Morrell[1] shows the following properties:

A. P. I. gravity	29.5°
Furol viscosity at 77° F.	14 Sec.
Cold test	22° F.
Sulphur	1 per cent

Products derived from the crude oil:

	Per Cent
Gasoline	31.0
Kerosene	7.2
Gas oil	19.8
Lubricating oil	12.3
Paraffin wax	2.7
Pitch bottoms	25.0
Water	2.0

It was further stated that experiments showed a possible yield of 68.6 per cent gasoline from the crude by combined topping and cracking operations.

The oil is taken out by pipe lines to the Pacific Ocean at Ventura, where it is loaded on tankers, either from the wharf or through a submarine pipe line laid on the ocean bed a half mile into the sea.

The gas-oil ratio in the Ventura Avenue field at present (January, 1928) is slightly less than 4,000 cubic feet per barrel of oil. In the earlier history of the field the gas-oil ratio was approximately 1,000 cubic feet per barrel but has gradually risen to the present figures.

The gas-oil ratio of the wells depends roughly on their position on the structure, being greatest in those near the top of the structure, decreasing in the wells farther down the flanks of the fold.

[1]Gustav Egloff and Jacques C. Morrell, "Refining of Ventura Avenue Crude," *Oil and Gas Journal*, Vol. 26, No. 8 (July 14, 1927), p. 130.

Although the wells of greatest gas-oil ratio are on the axis of the anticline they are about 3,000 feet east of the dome of the anticline. Thus the gas crest and the structural crest do not coincide. Some wells near the top of the structure have had gas-oil ratios as high as 30,000 cubic feet per barrel of oil, while others on the flanks of the anticline show as low as 500 cubic feet per barrel of oil.

The general analysis of the gas in the Ventura Avenue oil field is as follows:

	Per Cent
Methane	83.0
Ethane	12.0
Propane or heavier	4.c
Carbon dioxide	0.8
Oxygen, hydrogen, and nitrogen	0.2

Gasoline is extracted from the gas at absorption plants on the leases. Approximately one gallon of gasoline per 1,000 cubic feet of gas is recovered. Some of the gasoline is shipped in tank cars and trucks to different refineries, but the Shell Company has a 4-inch gasoline line to its refinery at Wilmington, 80 miles away.

A small amount of dry gas is used in Ventura and the surrounding towns of Santa Barbara, Oxnard, and Santa Paula. A greater amount, however, is taken care of by two 12-inch pipe lines with a capacity of 30,000,000 cubic feet per day each and one 15-inch pipe line with a capacity of 50,000,000 cubic feet per day to Los Angeles, 80 miles south. Besides these outlets and the field use of the gas, there is still some surplus.

Up to January 1, 1928, the Ventura Avenue oil field has produced nearly 44,000,000 barrels of oil. Table II shows the production of the field by years to date.

FUTURE DEVELOPMENT

Future production depends upon how far beyond its present limits the field is extended, upon how rapidly the controlling companies decide to drill, and upon how deep the oil sands reach. Although the writer does not believe that the Ventura Avenue field will ever have a phenomenally large daily production, probably never yielding 100,000 barrels per day, it is easily capable of reaching this figure with intensive drilling. However, five years from now, or even ten, when the depth of Pico oil sands may have been determined, and with possible production from the Miocene formations, the Ventura Avenue field will still be a factor in California's oil production. The ultimate production cannot be pre-

TABLE II

	Year	Production	Average per Day	Number of Wells
	1917	1,155	3	1
Total		1,155		
	1918	18,949	52	4
Total		20,149		
	1919	40,285	110	4
Total		60,434		
	1920	106,737	319	8
Total		167,171		
	1921	132,440	363	12
Total		299,611		
	1922	710,987	1,948	18
Total		1,010,598		
	1923	1,409,110	3,861	22
Total		2,419,708		
	1924	1,836,445	5,018	30
Total		4,256,153		
	1925	7,020,189	19,233	53
Total		11,276,342		
	1926	14,862,805	40,720	82
Total		26,139,147		
	1927	17,859,688	48,931	123
Total		43,998,835		

dicted with any degree of certainty, but it may be safely said that it will be more than 250,000,000 barrels of oil and more than 600,000,000,000 cubic feet of gas.

ORIGIN OF THE SESPE FORMATION OF SOUTH MOUNTAIN, CALIFORNIA[1]

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ABSTRACT

Mechanical analyses of rock samples, field observation of features such as cross-bedding, and reports of other investigators lead the writer to the conclusion that the Sespe formation originated as an alluvial-fan deposit, under warm, semi-arid conditions.

The stratigraphic relations of the Sespe formation of South Mountain, Ventura County, California, are shown in the accompanying columnar section (Fig. 1). The greater part of the Sespe is probably Oligocene in age, although the uppermost 600 feet may be lower Miocene, according to Stock and Furlong,[3] who report vertebrate fossils, assigned to the genera *Promerycochoerus* and *Leptauchenia*, from the formation at this locality. Although well borings show that this deposit is probably more than 5,000 feet thick, only 1,560 feet are exposed in the area examined, in and near the South Mountain oil field. Above the Sespe lies a basic igneous rock, probably an auganite flow, which is succeeded by Vaqueros sandstone containing characteristic fossils.

The results of mechanical analyses of several typical rock samples from the Sespe formation are shown by the accompanying histograms (Fig. 2). The sandstone (No. 1) is characterized by little assortment, with grain sizes ranging from fine to coarse, but the greater number of grains have diameters ranging from .503 to .833 millimeters. The conglomerate matrix (No. 2) shows even less assortment than the sandstone. The histogram illustrates the increase in the number of fine and coarse grains, and a corresponding decrease in those of medium size. The maximum diameter is between .208 and .381 millimeters. The histogram of the shale sample (No. 3) exhibits better assortment than is found

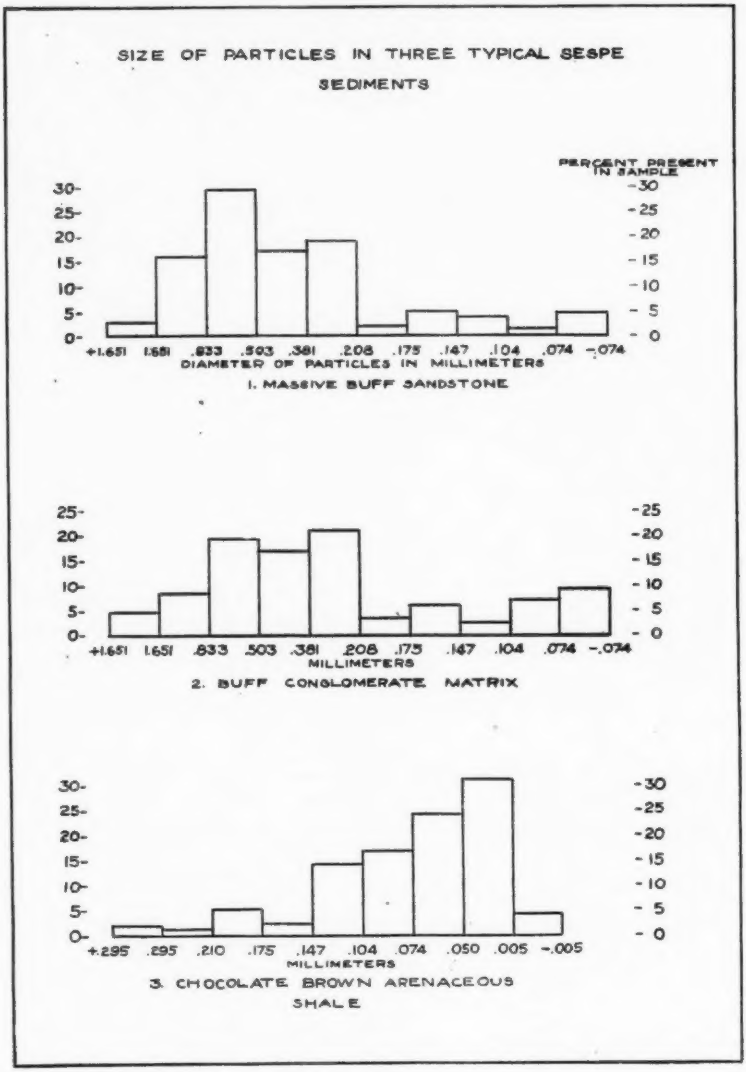
[1]Paper received by the editor, March 29, 1928.

[2]Introduced by Eliot Blackwelder.

[3]Chester Stock and E. L. Furlong, paper read before the Geol. Soc. Amer., Cordilleran Section, Los Angeles meeting, December, 1926.

COLUMNAR SECTION, NORTH SIDE OF SOUTH MOUNTAIN				
SERIES	FORMATION	COLUMN	THICKNESS (FEET)	DESCRIPTION
LOWER MIOCENE	VAQUEROS		0-400	Marine sandstone with characteristic fossils
LOWER MIOCENE	AUGANITE (?)		275	Dark grey in color, stained red at the surface. Considerably fractured, and cemented by light gray, calcareous cement. Composed chiefly of plagioclase embedded in a glassy matrix, with some pyrite, magnetite, and calcite. Rock is probably a glassy auganite. Occurs as a flow.
LOWER MIOCENE	ESPEE		600	GENERAL DESCRIPTION Sandstone, shale, and conglomerate, generally intergraded. Sandstone and conglomerate occur at the top and near the bottom of the column, and shale is found in the center, interbedded with argillaceous sandstone. All sediments cross-bedded and very lenticular. Contain a few vertebrate fossils. SANDSTONE Ordinarily buff colored; in places gray or chocolate brown. Gray and buff sandstone in many places stained brown at surface. Occurs in beds ranging from 4 to 30 feet thick; a few in very thin layers. Slightly fractured. Ranges from fine to coarse, this change being distinct in a distance of a few feet or less. Occurs interbedded with shale and conglomerate. Composed chiefly of quartz and feldspar, with minor amounts of serpentine, biotite, and calcite. Loosely cemented by calcite and ferric oxide. SHALE Chocolate brown, blue, gray, or pink. Ranges in physical properties from hard, dense and waxy to soft and arenaceous. Waxy shale has bedding planes 2 or more inches apart; sandy shale is generally laminated. Composed chiefly of quartz, serpentine, chalcedony, and kyanite, with some biotite and opal. Calcite and ferric oxide cement. May occur fractured. CONGLOMERATE Occurs in lenses rarely as thick as 2 feet, interbedded and intergraded with the sandstone. Pebbles are sub-rounded, ranging in diameter from 1/4 inch to 6 inches. Composed mainly of chert with some quartz and rhyolite. Matrix is coarse, buff sandstone, composed chiefly of feldspar, with smaller amounts of biotite, muscovite, quartz, and chalcedony. Loosely cemented with calcite and ferric oxide. Contains but few joints.
OLIGOCENE (?)	ESPEE		960 +	

FIG. 1



SIZE OF PARTICLES IN THREE TYPICAL SESPE SEDIMENTS
PERCENT PRESENT IN SAMPLE
30- 25- 20- 15- 10- 5- 0-
+1.651 1.651 .833 .503 .381 .208 .175 .147 .104 .074 -.074
DIAMETER OF PARTICLES IN MILLIMETERS
1. MASSIVE BUFF SANDSTONE
25- 20- 15- 10- 5- 0-
+1.651 1.651 .833 .503 .381 .208 .175 .147 .104 .074 -.074
MILLIMETERS
2. BUFF CONGLOMERATE MATRIX
30- 25- 20- 15- 10- 5- 0-
+.295 .295 .210 .175 .147 .104 .074 .050 .005 -.005
MILLIMETERS
3. CHOCOLATE BROWN ARENACEOUS SHALE

FIG. 2

in the other rocks, as most of the material is silt and fine sand, with the maximum diameter between .005 and .050 millimeters.

These analyses make it apparent that the sediments are terrestrial rather than marine in origin, for in marine deposits the assortment is much better than that here developed. Confirmatory evidence of the terrestrial origin of the formation is afforded by the extensive cross-bedding, lenticularity of the strata, as proved by areal mapping, lack of marine fossils, and the presence of the two genera of land vertebrates previously named. As to the type of terrestrial deposit represented, field study indicates that the Sespe formation, as exposed on South Mountain, is part of an old alluvial fan. The most important evidence for this conclusion, aside from the degree of assortment, is the type of bedding exhibited. The strata are so lenticular that in many cases thick beds can be traced only for short distances, as is the case in alluvial fan deposits. Since Kew[1] has already suggested that the Sespe is of alluvial fan origin, the present study serves merely to bring forward supporting evidence.

The climate that existed at the time of deposition is suggested by the undecomposed condition of the feldspars and other chemically susceptible minerals, and by the red color of the sediments. From these facts it is inferred that the climate probably was warm and semi-arid. This view agrees with that expressed by Clark and Arnold,[2] who have stated that the marine Oligocene of California was deposited under warm temperate conditions; and since there is some evidence that at least part of the Sespe formation in the western Santa Ynez Range is contemporaneous with marine Oligocene strata, this conclusion regarding climate seems to be of more than local significance.

[1] W. S. W. Kew, "Geology and Oil Resources of a Part of Los Angeles and Ventura Counties, Calif." *U. S. Geol. Survey Bull.* 753, 1924, p. 30.

[2] B. L. Clark and Ralph Arnold, "Marine Oligocene of the West Coast of North America," *Bull. Geol. Soc. Amer.*, Vol. 29 (1918), p. 306.

MINERALS OF SESPE FORMATION, CALIFORNIA, AND THEIR BEARING ON ITS ORIGIN[1]

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ABSTRACT

A representative sample from the Sespe formation, from the Upper Ojai valley, California, was examined as to its mineral content and the following minerals were found: quartz, feldspars, calcite, muscovite, epidote, lawsonite, garnet, zircon, glaucophane, cyanite, pyroxene, tremolite, serpentine, topaz, biotite, chromite, chlorite, spinel, rutile, monazite, tourmaline, hematite, limonite, and magnetite.

Most of these minerals are characteristic of metamorphic and granitic rocks and are strikingly similar to those which are typical of the Franciscan series. They suggest that the Sespe formation was largely derived from the Franciscan rocks and that the latter were probably widely exposed throughout the southern Coast Ranges during Sespe time. The freshness and angularity of most of the mineral grains indicates a short transportation and a lack of chemical weathering. These features point to the accumulation of the Sespe formation under continental conditions such as prevail during a semi-arid climate.

The Sespe formation,[3] because of its brilliant coloring and wide exposures, is one of the most spectacular formations encountered in southern California. Study of the formation has long interested geologists because of the striking character of the strata and the relation of the formation to petroleum production in several fields. The Sespe formation contains several oil-bearing horizons and in addition overlies producing sands in several places. It has lately come into special prominence through the discovery of petroleum in this formation in the Goleta oil field, near Santa Barbara. As a result of this discovery drilling has become somewhat more active in the Sespe formation in the surrounding districts.

Two types of the Sespe formation are recognized in southern California, one occurring north of Santa Clara River, and the other exposed to the south of the river. According to Eldridge[4] the upper zone of the

[1]Manuscript received by the editor, April 9, 1928.

[2]50 Morningside Drive. Introduced by J. J. Galloway, Columbia University.

[3]The Sespe formation (Oligocene?) overlies the Tejon (Eocene) and in turn is overlain by the Vaqueros formation (Miocene).

[4]H. E. Eldridge and Ralph Arnold, "The Santa Clara Valley, Puente Hills, and Los Angeles Oil Districts, Southern California," *U. S. Geol. Survey Bull. 309*, 1907, p. 9.

Sespe on the north side of the Lower Ojai valley consists of rusty sandstones and red to gray beds of sandstone with shale layers. These beds contain scattered pebbles. At South Mountain,[1] south of Santa Clara River and about 11 miles southeast of the Upper Ojai valley, the Sespe formation has massive yellow and brown sandstone and conglomerate interbedded with soft sand and clay, colored red, green, gray, and white. The outstanding characteristics of the strata exposed at South Mountain are bad-land topography and broad color banding. North of Santa Clara River the exposures are more resistant to erosion and the color is more uniformly brown.

Since the Sespe formation is entirely of detrital origin and nonfossiliferous, a study of the minerals it contains assumes importance. The formation is exceptionally rich in the variety of its minerals. An examination has been made of representative material,[2] from the upper Sespe formation, in a well-exposed section, about 3 miles east of Ojai, along the Ventura County highway on the grade between the Upper and Lower Ojai valleys. The samples consisted of gray medium- to fine-grained sandstone, dark reddish-brown fine sandstone, and brown shale. Most of the sands were friable but some were well cemented. In places the shale has thin layers which are rich in muscovite.

METHOD OF TREATMENT

The sample was carefully broken down in a mortar so as to separate the grains without crushing them. The material was then treated with dilute hydrochloric acid until the particles were almost entirely freed from their iron oxide coating. During the acid treatment the samples lost about a fourth in weight due to the solution of iron oxides and carbonates. The carbonates were present chiefly as grains of calcite in the coarser sands, but also as a cementing material. The residue from the acid treatment was separated,[3] with the use of bromoform, into light and heavy fractions. The lighter portion was composed principally of quartz and feldspars. The heavy portion was in part mounted on glass slides and the remainder left free for use in isolating individual grains for identification.

[1] W. S. W. Kew, "Geology and Oil Resources of a Part of Los Angeles and Ventura Counties, California," *U. S. Geol. Survey Bull. 753*, 1924, p. 172.

[2] The writer wishes to acknowledge his indebtedness to Prof. Paul F. Kerr, of Columbia University, for samples of the Sespe formation and for valued suggestions and constructive criticism during this investigation.

[3] H. B. Milner, *An Introduction to Sedimentary Petrology*, London, 1922; *Supplement to an Introduction to Sedimentary Petrology*, London, 1926.

HEAVY MINERALS OF THE SESPE FORMATION

The Sespe formation contains an assemblage of heavy minerals which are of interest, not only because of their value as a means of correlation, but also because they are indicative of the origin, and conditions of deposition, of the formation. Minerals from the heavy portion include muscovite, epidote, lawsonite, garnet, zircon, cyanite, glaucophane, topaz, biotite, chromite, pyroxene, tremolite, serpentine, chlorite, spinel, rutile, monazite, tourmaline, hematite, limonite, and magnetite. Calcite occurs in the samples in considerable quantity as grains and somewhat as cement but was entirely dissolved out during the acid treatment. Such an assemblage contains several minerals which are rare in sediments. The first eight of these are probably the more characteristic, while the remainder are less typical or present in lesser amounts. Some of the more important minerals are listed below with a resumé of their outstanding characteristics which, in this occurrence, proved to be of assistance in their identification.

Epidote.—Epidote is present in numerous light greenish-yellow grains showing faint pleochroism. The grains tend to be cloudy except on the edges. Cleavage is fairly well developed in most of the particles, causing a tendency to orientation on (001) in the mounted grains, so that many of them give good, though faint, optic-axis interference figures. The axial bar is nearly straight, indicating the large optic angle. High dispersion may prevent obtaining complete extinction. This feature is observed in some minerals of high dispersion where occurring as sand grains, because some of these are much thicker than the same mineral would be in the ordinary thin section.

Lawsonite.—Many greenish-yellow to colorless grains with good cleavage, angular outlines, and elongate inclusions, are lawsonite. The inclusions tend to a parallel arrangement and in some cases cause cloudiness. Good interference figures are obtained and they are as a rule nearly perpendicular to an optic axis. The resulting axial bar shows the optic angle to be large and the mineral to be positive. The cleavage is well developed and the surface is minutely irregular. This latter feature is an aid in distinguishing lawsonite from other minerals of somewhat similar appearance.

Garnet.—Garnet is not plentiful, but many grains and a few crystals were identified. Garnet has a strong relief, irregular fracture, is generally pink to flesh-colored, rarely brown, and is optically isotropic.

Zircon.—Crystals of zircon are rather plentiful and there are a few somewhat rounded fragments and grains. Zircon is easily recognized

by its characteristic tetragonal crystals, parallel extinction, high relief, and extreme birefringence.

Glaucophane.—A few grains of glaucophane are present in each mount and its blue color, strong blue to violet pleochroism and low birefringence make its determination a simple matter. It occurs in prismatic, generally unaltered, grains which give very low extinction angles. The mineral is optically positive with an optic angle near to 40°. In one heavy fraction an interesting mineral grain was found. This possessed similar optical properties to glaucophane but with its mean index of refraction, β higher than 1.65 and less than 1.66. The indices of normal glaucophane[1] are: $\alpha = 1.621$, β, $= 1.638$, $\gamma = 1.638$. $2V$ is near to 40°. Specimens[2] of glaucophane from Syra, Greece; St. Marcel, Piedmont, Italy; and San Benito County, California, were tested, all of them showing the index of refraction β below 1.64. This amphibole is either a variety of glaucophane with a higher index than is commonly given for that mineral or is possibly a distinct species. Woodford[3] mentioned a similar mineral occurring in the San Onofre Mountain region, California.

Cyanite.—Clear to translucent, colorless, nearly rectangular, fragments of cyanite are fairly plentiful. These show good cleavage, parallel to (100) and (001) and some contain many minute inclusions. The index of refraction is high ($\beta = 1.72$); the birefringence is low (0.012), and the extinction angle of about 30° is distinctive. These properties serve easily to identify cyanite in a mount of mineral grains.

Chromite.—Chromite occurs in irregular grains which are dark and opaque, except on thin edges where it is translucent, or dark brown in color.

Spinel.—Spinel is present in small octahedrons with rough dull surfaces. Some of the fragments are semi-transparent, dark brown and isotropic, and are probably picotite.

Tourmaline.—Tourmaline occurs as black, opaque crystals and as pleochroic, clear to dark brown grains. The strong absorption at 90° to the elongation is distinctive.

Iron oxides.—Hematite and limonite are present in considerable quantity in the heavy residue. Limonite also coats many of the other

[1] E. S. Larsen, "The Microscopic Determination of the Non-Opaque Minerals," *U. S. Geol. Survey Bull. 679*, 1921, p. 258.

[2] These specimens were furnished from the Egleston Collection of Columbia University.

[3] O. A. Woodford, "The San Onofre Breccia, Its Nature and Origin," *Univ. Calif. Pub., Bull. Dept. Geol.*, Vol. 15, 1925, p. 190.

mineral grains, but was removed almost entirely with the acid treatment which would also tend to dissolve some of the limonite occurring in grains. A test with a magnet shows magnetite to be but sparsely distributed in the samples. The almost complete absence of magnetite is noteworthy.

ORIGIN OF THE SESPE MINERALS

This assemblage of minerals yields at least partial evidence concerning the origin of the Sespe formation, since a similar group of minerals is characteristic of the Franciscan series. The nearest known exposure of the Franciscan rocks[1] (Jurassic?) is about 20 miles to the west along the Santa Ynez River canyon. Rocks similar to those of the Franciscan series are known on the Channel Islands,[2] just off the coast of southern California. Although not exposed in the immediate vicinity of the Ojai valley, the Franciscan series of rocks is probably one of the underlying formations of the district because of its wide extent[3] along the California coast. During Sespe time the Franciscan series was probably more extensively exposed along the southern part of the Coast Ranges. Eldridge[4] states that the Vaqueros formation (Miocene), which overlies the Sespe formation in the Ojai valley, contains pebbles which were probably derived from a near-by exposure of the Franciscan series. Woodford[5] described exposures of rocks of the Franciscan type from Santa Catalina Island and on San Pedro Hill on the adjacent mainland.

TRANSPORTATION AND DEPOSITION

Some of the garnet and zircon from the Sespe formation shows well developed rounding, as contrasted with the lack of rounding of the less resistant minerals in the same deposit, which demonstrates that they have been subjected to considerable rolling. This suggests that part of the garnet and zircon was derived directly from metamorphic or granitic rocks, along with the other angular minerals present, while the rounded

[1] R. N. Nelson, "Geology of the Hydrographic Basin of the Upper Santa Ynez River, California," *Univ. Calif. Pub., Bull. Dept. Geol.*, Vol. 15 (1925), p. 334.

[2] W. A. Goodyear, *Ninth Ann. Rept. of the State Mineralogist* (1889), *Calif. State Min. Bur.*, 1890.

[3] J. P. Smith, *Geologic Map of the State of California* (1916), *Calif. State Min. Bur.*, 1917.

[4] H. E. Eldridge and Ralph Arnold, "The Santa Clara Valley, Puente Hills, and Los Angeles Oil Districts, Southern California," *U. S. Geol. Survey Bull. 309*, 1907, p. 13.

[5] A. O. Woodford, "The Catalina Metamorphic Facies of the Franciscan Series," *Univ. Calif. Pub., Bull. Dept. Geol.*, Vol. 15 (1924), p. 49.

forms may have been eroded from previously deposited sediments such as the Knoxville (Lower Cretaceous) or the Franciscan sandstone. Davis[1] and Trask[2] mention the occurrence of pink and flesh-colored garnets in the Franciscan sandstone. Those found by Trask at Point Sur were thought, from their similarity to those occurring in the Sur series, to have been derived from these old metamorphic rocks.

The glaucophane, pyroxene, and other more easily abraded minerals from the Sespe formation are remarkably fresh and free from evidence of chemical weathering or long transportation. This feature and the angular nature of most of the grains indicate that the Sespe material was very likely accumulated under conditions such as prevail during a semi-arid climate, and deposited as a continental sediment near the rocks from which it was derived. This conclusion agrees with the observations of Kew,[3] in his description of the Santa Ynez River district, where he regarded the Sespe formation as having been formed, under arid conditions, in a basin surrounded by steep slopes of Franciscan rocks. The criteria on which he based his conclusions were: the type of cross-bedding, the lack of fossils, and the lithological character of the deposit. According to Kew, the base of the Sespe formation is a fanglomerate largely composed of fragments of Franciscan rocks. The conditions there indicated that the upper Sespe graded upward into the lower Miocene without interruption as the sea transgressed upon the land. Trask[4] found, in the Point Sur area, red continental beds of the Temblor (Miocene) grading upward into a fossiliferous marine facies. These observations point to a transgression of the Miocene sea over the formations which had accumulated upon the land under somewhat arid conditions, thus bringing to a close the period of continental deposition.

[1] E. F. Davis, "The Franciscan Sandstone," *Univ. Calif. Pub., Bull. Dept. Geol.*, Vol. 11 (1918), p. 20.

[2] P. D. Trask, "Geology of the Point Sur Quadrangle, California," *Univ. Calif. Pub., Bull. Dept. Geol.*, Vol. 16 (1926), p. 137.

[3] W. S. W. Kew, "Geology of a Part of the Santa Ynez River District," *Univ Calif. Pub., Bull. Dept. Geol.*, Vol. 12 (1919), pp. 12-13.

[4] P. D. Trask, *op. cit.*, p. 148.

FORAMINIFERAL SECTION ALONG ADAMS CANYON, VENTURA COUNTY, CALIFORNIA[1]

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ABSTRACT

Sixty-one samples were collected and studied for their micro-faunal variations. *Foraminifera* composed the principal faunal content, although gastropods, pelecypods, echinoid spines, and ostracods were also present. A chart shows the major lithologic features and variations in fossil content. *Foraminifera* indicate the entire series of sediments within this section of Adams Canyon to be Pliocene in age. The micro-faunal sequence shows that this great thickness of sediments is not due to a repetition of beds. The foraminiferal contact between the upper and lower Pico members and corresponding zonal changes have been located in wells within the Los Angeles basin and Ventura areas.

Adams Canyon is one of several canyons which serve as drainage channels from the south side of Sulphur Mountain to the Santa Clara River valley. The town of Santa Paula lies approximately 1¼ miles east of the mouth of this canyon. A rather bumpy dirt road permits automobile transportation almost to the head of the canyon.

The physiography is typical of youthful topographic features developed under semi-arid climatic conditions. Stream cutting has been rather rapid, leaving excellent exposures along the greater portion of its course and forming rather rugged outcrops in the harder strata through which gorges several feet in depth have been cut at approximately right angles to the strike of the beds. Most of the hills, especially near the mouth of the canyon, are somewhat rounded in profile. Slumping has commonly resulted along some of the steeper slopes. The section traversed ranges in elevation from 400 to 1,000 feet.

The writer is indebted to W. S. W. Kew for calling attention to the merits of this section and also for his aid in collecting samples, and for geologic notes.

GEOLOGY

The notable geologic features are the uniformity of the strike and dip of the beds and the great thickness of the sediments. Nowhere in

[1]Read before the Pacific section of the Association at Los Angeles, October 29, 1926, by permission of the Standard Oil Company of California. Manuscript received by the editor, April 1, 1928.

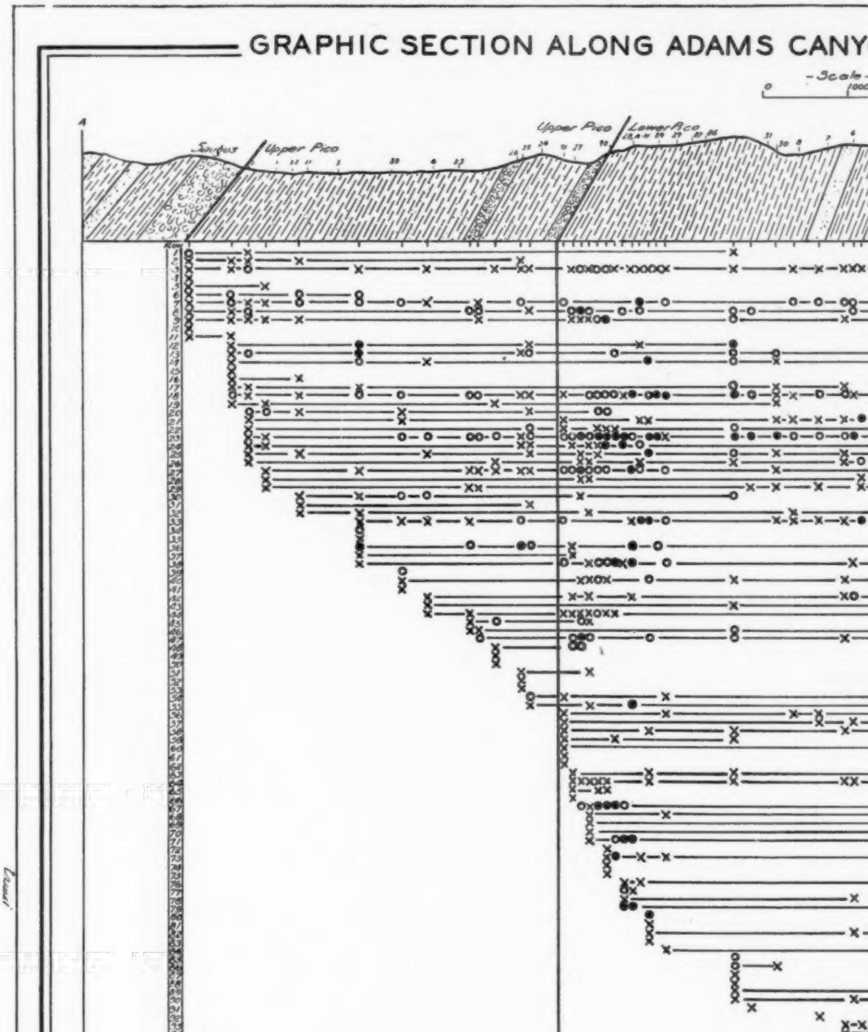
[2]Standard Oil Company of California.

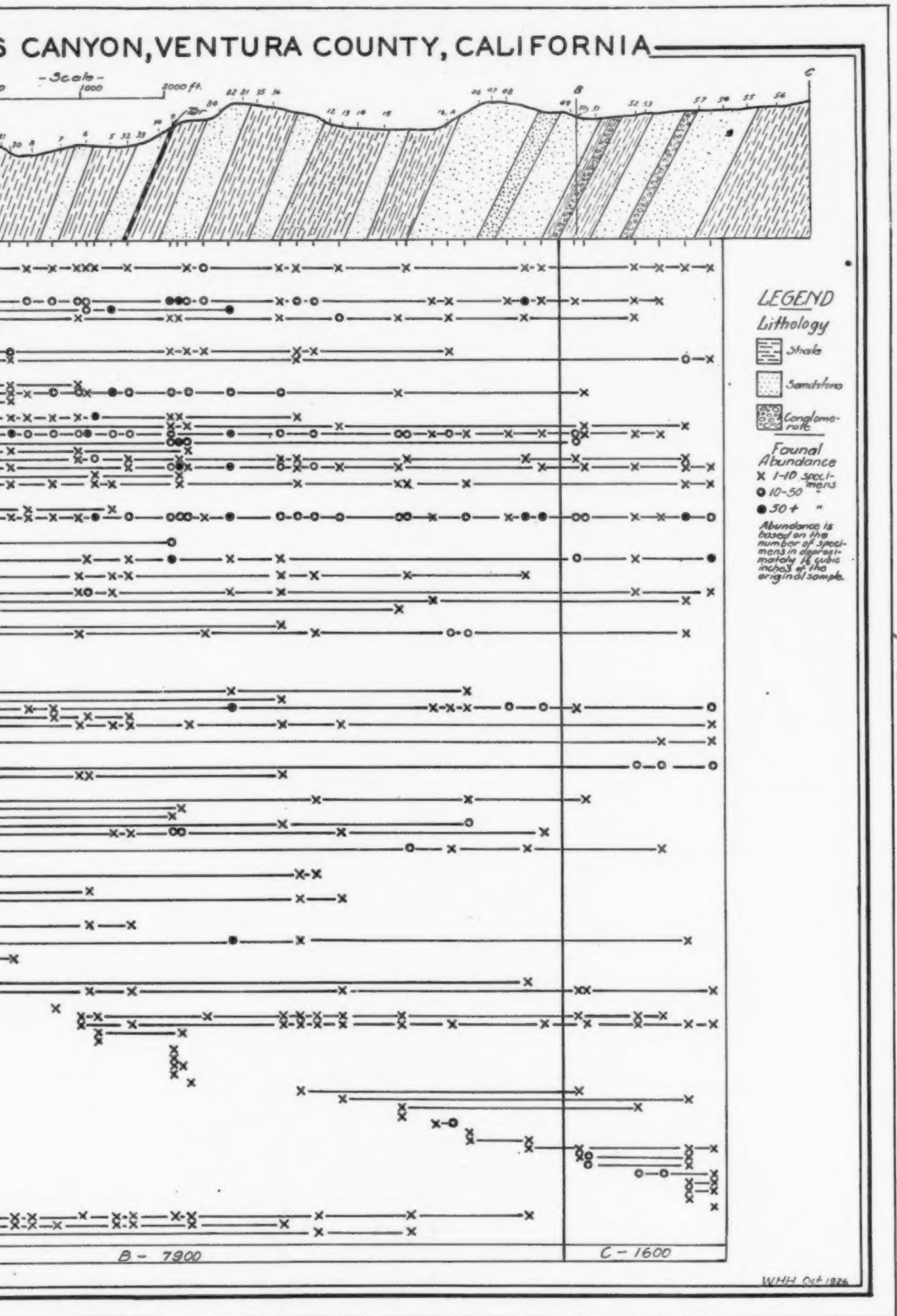
California, or elsewhere so far as known, is such a thickness of Pliocene in a continuous section so well exposed. The Saugus formation is present at the extreme southern end of this section and the remaining portion, representing a thickness of more than 13,700 feet, is made up of sediments referable to lower Pliocene. The Saugus conformably overlies the Pico and is marked at the base by a massive conglomerate. No fossils were found in the Saugus within this canyon, but the underlying sediments contain a plentiful micro-fauna. The beds range in strike from N. 60° to 85° E., and in dip from 50° S. in the Saugus to 68° S. in the older strata. The northern limit of this section marks the lowermost Pliocene outcrop. A little north of this point the Miocene of Sulphur Mountain has been thrust over the Pliocene by southerly directed pressure which has resulted in the tilting of the younger beds. A thin, practically horizontal covering of recent detrital material unconformably overlies the uptilted beds within portions of the canyon.

SAMPLES

Sixty-one samples were collected along Adams Canyon with the object of making a study of the variations in the micro-fauna. Samples 1 and 2 were obtained near the Saugus contact on the ridge at the east side of Fagan Canyon where there were better exposures of these beds. Fagan Canyon lies immediately east of Adams Canyon. Very little selecting was required to obtain samples showing the presence of foraminifers by means of a hand-lens examination. Organisms were found to be most plentiful in the more shaly beds.

The accompanying chart (Plate 6) graphically shows the major lithologic features and the variation in micro-faunal content. The numbers along the surface of the section represent the projected sample localities along the line of section which commences at point *A*, 4,400 feet N. 24° W. from the intersection of the Adams Canyon road with the road along the base of the hills as shown on the Santa Paula quadrangle topographic sheet, and extends 15,100 feet N. 8° E. to point *B*, from which the section strikes N. 42° W. for a distance of 2,400 feet. The micro-faunal content is indicated in vertical columns as closely underlying the projected locations of the respective samples at the base of the section as the cross sections and intervals between samples permit. With the exception of the variations to be mentioned later, each horizontal row indicates the occurrence of one distinctive form. The faunal content based on observation of the washed portions remaining after treating about 1½ cubic inches of the original material is approximately


GRAPHIC SECTION ALONG ADAMS CANY
-Scale-
Saugus
Upper Pico
Upper Pico
Lower Pico
Mollusca
Echinoids
Ostracods
Zones
A - 4250'


S CANYON, VENTURA COUNTY, CALIFORNIA
C
B
-Scale-
1000
2000 ft.
LEGEND
Lithology
Shale
Sandstone
Conglomerate
Faunal Abundance
x 1-10 specimens
o 10-50 "
● 50+ "
Abundance is based on the number of specimens in approximately ½ cubic inches of the original sample.
B - 7900
C - 1600
WHH Oct 1926
Trim
Trim

shown in accordance with the symbols indicated in the legend on the chart. This indicated content does not necessarily denote the actual abundance of the organisms, for many of the forms have been crushed or partially leached so that they fall apart when the shale is digested and other specimens may have suffered weathering to such an extent that their presence is indicated merely as molds within the shale. The apparent scarcity of fauna in the northern end of this section is due primarily to many of the forms having been crushed and subjected to more complete weathering. Horizontal lines have been drawn between the symbols of abundance in order to aid in recognizing zonal changes. The micro-faunal content has been listed for each sample consecutively from south to north, thus furnishing a vertical sequence in echelon pattern as additional forms were obtained in subsequent samples.

An inspection of the chart shows that many of the forms are persistent throughout this section. The forms indicated by rows 3, 7, 14, 27, and 29 are examples. This continuation of fauna is to be expected in a series of sediments of the same geologic age. The use of *Foraminifera* for correlation purposes is put to an extreme test when dealing with such massive sediments as are encountered in the Pliocene of this locality.

A closer inspection of the chart reveals that *Foraminifera* may be a useful aid in correlating even these massive deposits. The fauna of no two samples is identical. Even the group of samples collected at locality 28, where the interval between any two is not more than 50 feet, shows a faunal difference. Most of the variation within this group is probably due to the fact that the particular forms considered were not observed or were not well enough preserved to identify them in the parts of the samples examined. On the other hand, other faunal variations are shown to be too pronounced or too persistent to be due merely to a function of preservation or the degree of inspection. No forms below row 55 were found south of sample 90. Forms represented by rows 40, 71, and 89 are found in samples 50 or 51 but apparently not farther north. Also, the forms represented by rows 110 to 116 have not been found as far south as sample 51. The fauna may then be roughly grouped into three main zones, *A*, *B*, and *C*, having an approximate thickness of 4,250, 7,900, and 1,600 feet, respectively. Conglomeratic phases indicate corresponding lithologic breaks.

The faunal changes between zones *A* and *B* mark the contact between the upper and lower Pico members. The change between zones *B* and *C* is considered to be a zonal division within the lower Pico member. The term lower Pico has been adopted after comparing *Foraminifera*

from samples taken near the base of the type Pico in Pico Canyon with the fauna found in zones *B* and *C* of this section. Almost 20 per cent of the extractable *Foraminifera* in sample 56 are Miocene forms. A study of the organisms in place within the shale shows that this high percentage of Miocene *Foraminifera* is misleading, for there is a preponderance of poorly preserved forms which are apparently lower Pico in age. Most of the Miocene specimens have been filled with calcite, which probably accounts for their preservation. As indicated in row 56, these adventitious Miocene forms are observed even in the upper Pico member.

Organisms other than *Foraminifera* were noticed, but they were much less plentiful. The occurrences of gastropods, pelecypods, echinoid spines, and ostracods are shown at the bottom of the chart. No exhaustive search was made for specimens of mollusks. These occurrences are of unidentifiable fragments which were washed out of the samples during treatment for foraminiferal study. Bryozoan fragments were observed in samples 31 and 50. Partially pyritized and carbonized plant remains are present in most of the samples. Sample 81 contains well preserved leaf impressions.

STRATIGRAPHIC RELATIONS

Foraminifera indicate the entire series of sediments within this section of Adams Canyon to be Pliocene in age. The micro-faunal sequence shows that this great thickness of sediments is not due to a repetition of beds. The foraminiferal contact between the upper and lower Pico members and corresponding zonal changes have been located in wells within the Los Angeles basin and Ventura areas.

AN EXTENSION OF THE ROSE DOME INTRUSIVES, KANSAS[1]

W. H. TWENHOFEL[2] AND BERNARD BREMER[2]
Madison, Wisconsin

ABSTRACT

A well drilled in Woodson County, Kansas, about 3 miles southeast of the outcrop of the granite porphyry intrusive of the Rose dome, penetrated a black rock through a thickness of 102 feet, or from the depth of 1,151 to 1,253 feet. This black rock is identified as a peridotite, as it is largely composed of olivine, brown mica, and a fine-grained brown aggregate which does not extinguish between crossed nicols. There seems to be no quartz or feldspar. It is suggested that the black rock is a dike or an intrusive sheet and connected in some way with the Rose dome intrusive.

Since the beginning of his acquaintance with the Rose dome of Woodson County, Kansas, and the quartzites of Silver City of the same county, the latter 6 miles southwest of the Rose dome, the senior writer has visited each of these areas as opportunity permitted and has endeavored to keep in touch with developments in the two regions. The quartzites of Silver City from their first discovery seem to have been correctly interpreted as having developed through hydrothermal action arising from the presence of an intrusive beneath the altered rocks. The granite blocks over the Rose dome at first were given an erroneous interpretation. Subsequently they were assigned to an intrusive origin and this interpretation has been sustained by all later evidence acquired by the senior writer from personal observation or from other geologists who have studied the Rose dome area. The various papers by the senior writer and collaborators on the Rose dome and Silver City areas are given in the footnote.[3]

It has been previously pointed out that a well, the Lieurance well, drilled about 300 yards northwest of the western edge of the largest group

[1]Paper received by the editor, April 16, 1928.

[2]Department of geology and geography, University of Wisconsin.

[3]W. H. Twenhofel, "The Silver City Quartzites, a Kansas Metamorphic Area," *Bull. Geol. Soc. Amer.*, Vol. 28 (1917), pp. 419-30; "Granite Boulders in (?) the Pennsylvanian of Kansas," *Amer. Jour. Sci.*, Vol. 43 (1917), pp. 363-80; "Additional Data Relating to the Granite Boulders of Southern Kansas," *Amer. Jour. Sci.*, Vol. 48 (1919), p. 132; "Intrusive Granite of the Rose Dome, Woodson County, Kansas," *Bull. Geol. Soc. Amer.*, Vol. 37 (1926), pp. 403-12; W. H. Twenhofel and E. C. Edwards, "The Metamorphic Rocks of Woodson County, Kansas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 5 (1921), pp. 64-74.

of boulders, contained in some of its samples small needle-like crystals of green diopside and fragments of a black rock composed of dark brown mica and dark pyroxene, the black rock being in samples from the depth of 1,380 feet to the bottom of the well at 1,685 feet. The black rock was not present in all of the samples between these two depths and only three samples were almost entirely composed of it, these being from depths of 1,436, 1,572, and 1,675 feet. In the paper in which the log of the well was described the minerals of the black rock and the green diopside were considered as having developed from contact metamorphism. In view of the data to be later presented, the opinion with respect to the dark brown mica and the dark pyroxene is revised and it is suggested that they were derived from small basic dikes encountered at several depths through a thickness of more than 200 feet. As the needles of green diopside were seen in place in the limestone particles it is quite certain that they developed as a consequence of contact metamorphism.

Through the kindness of Charles Studt, then with the Southwestern Gas Company of Independence, Kansas, the writer received a set of samples from a well drilled by the Southwestern Gas Company in the southwest corner of Sec. 31, R. 16 E., T. 26 S., the well being known as the Eagle No. 1. This well is about 1 mile east and 2¼ miles south of the occurrence of the Rose granites and 5 miles east of Silver City. The samples do not give the complete log, nothing being present from above 1,151 feet. The samples studied indicate that a basic igneous rock was penetrated in the well through a thickness of 102 feet, or from the depth of 1,151 feet to 1,253 feet. The log of the well as derived from the samples is as follows.

LOG OF SOUTHWESTERN GAS COMPANY'S EAGLE NO. 1

Samples	*Thickness in Feet*	*Depth in Feet*
Sample largely a fine-grained light brownish material containing quartz, brown mica, kaolin, and serpentine. This appears to be a partially decayed expression of the rock which is undecayed at 1,167 feet	3	1154
Sample like that from 1,151 to 1,154 feet except that less decay is shown and the particles have a browner color	13	1167
A little calcite and brown mica. Most of sample consists of fine-grained black rock containing dark brown mica	10	1177
A little calcite and brown mica; mostly composed of fine-grained black rock	23	1200
Fine-grained black rock containing plainly visible flakes of dark brown mica	20	1220

LOG OF SOUTHWESTERN GAS COMPANY'S EAGLE NO. 1—*Continued*

Samples	*Thickness in Feet*	*Depth in Feet*
Fine-grained black rock, one sample contains fragments as large as a centimeter in diameter	30	1250
Very finely ground black rock and black shale, much carbonate	3	1253
Hard dark gray shale and gray limestone	6	1259
Black shale, very little carbonate	7	1266
Gray limestone and chert and dark shale	4	1270
Soft dark gray to nearly black limestone and chert. Sample contains pyrite	14	1284
Gray to dark limestone	3	1287
Dark gray limestone and chert, many drill flakes	10	1297
Gray limestone	8	1305
Gray limestone and chert, many drill flakes	5	1310
Soft gray limestone	5	1315
Light gray limestone and chert, rocks nearly white	25	1340
White to gray limestone and chert, small range of color in different samples	35	1375
Gray limestone with a little light blue shale	3	1378
White limestone and chert	17	1395
Gray and white limestone with a few fragments of black shale	10	1405
Soft gray limestone	5	1410
White limestone with some chert	20	1430
Gray limestone with some light blue shale	5	1435
Gray limestone	5	1440
Gray and white limestone; chert in some samples, many without	66	1506
Light blue calcareous shale	24	1530
Soft blue-gray argillaceous limestone	15	1545
Gray limestone and a little chert	3	1548
Blue calcareous shale	3	1551
Black shale with a little limestone	24	1575
White limestone and chert with much green and black shale	5	1580
Light gray limestone with a little chert and black shale	5	1585
Gray limestone and chert	5	1590
Brownish-gray limestone (some dolomite) with some chert	6	1596
Gray limestone (some dolomite) and white chert	5	1601
White and gray limestone and white chert	39	1640

The log of this well from the depth of 1,253 feet to the bottom does not materially differ from the normal log for the pre-Pennsylvanian strata of this region. The well probably entered the "Mississippi lime" horizon at about the depth of 1,266 feet and may have entered older rock at about 1,580 feet. The part of the well below 1,253 feet shows normal sedimentary materials of which most are limestone and chert; some samples contain mica, quartz and pyrite, the quartz and mica probably being of detrital origin. All the limestones are fine-grained and some are soft and somewhat chalky. There is no evidence of anamorphism due to causes related to igneous intrusions or diastrophism.

From 1,151 to 1,253 feet the well penetrated a black rock composed of olivine, brown mica and a fine-grained brown aggregate which does not extinguish between crossed nicols. Olivine is very plentiful and in thin section has colors ranging from clear transparent to light bluish. Along contacts is it more or less altered to serpentine and perhaps chlorite. It is such alteration which probably is responsible for the samples described in the upper 16 feet of the log. The junior writer identified a white mineral resembling tremolite and a few grains of pyroxene and hornblende and he thought some inclusions in the brown mica might be magnetite. All mineral particles are small and few are visible without a microscope. The rock seems to contain no feldspar whatsoever and evidently is a fine-grained peridotite.

The character of the minerals and the nature of the rock as shown in the samples make it certain that this well penetrated a very basic igneous rock through a depth of about 100 feet. The fact that a normal unaltered pre-Pennsylvanian sequence lies below the igneous rock shows that the latter is a dike, sheet, or flow. It is possible that it is a flow extruded following the deposition of the Mississippian and preceding that of the Pennsylvanian sediments. This interpretation of origin is favored by the smallness of the mineral particles and the alteration of the rock where it is entered by the well, but the absence of glass and any evidence of vesicular texture is not in accord with such an interpretation. While the facts are not to any large degree decisive, it is not considered a flow, but an intrusive body. In case it is a flow, the distance the well was drilled through the black rock, 102 feet, probably approximates the thickness. The same may be said in case the rock is an intrusive sheet. If the igneous body is in the form of a dike, the thickness can not be determined from any data in the writers' possession. It may be very thin and in a position not inclined many degrees from vertical. The fact that the Lieurance well, immediately northwest of the Rose dome granites, showed fragments of black rock like those of the Eagle No. 1 well, although olivine is not a chief component, suggests that small dikes were encountered in that well at several levels. It will be remembered that in a well drilled in section 24, T. 26 S., R. 16 E., about a mile southwest of the Rose granites, a "dacite dike" was reported. The samples purporting to have been derived from the dike were studied by E. C. Edwards and the senior writer, but not one of them contained any minerals indicating the presence of a dike. In view of the facts that have come to light since the drilling of the well in section 24, it is suspected that the samples studied by Mr. Edwards and the senior writer did not represent

the horizons where the reported dike was encountered and, if such was the case, the results of the studies of the samples would have no bearing on its presence.[1]

If the rock in the well is an intrusive sheet and was intruded subsequent to the deposition of the surface strata there should be indications of this in the structure of the overlying strata as these would have been lifted above their normal stratigraphic position a distance approximating the thickness of the sheet. This may be shown in the surface structure, but no data in the writers' possession permit such a lifting to be postulated. If the igneous body is a dike it is possible that it is not of great thickness and hence would have little structural effect on the surface rocks.

If the igneous rock in the Southwestern Gas Company's well is intrusive, one may speculate as to the nature of the parent body and the distance the intrusion extended therefrom. The only intrusive certainly known in this region is the granite porphyry of the Rose dome. This is known to be steep-sided on the northwest to the depth of the Lieurance well, 1,685 feet; but it may have considerable underground eastward extension. If such is not the case, the intrusive body encountered in the Southwestern Gas Company well must have penetrated the sediments for a mile or more. It has been postulated that an igneous body underlies the metamorphic rocks at Silver City, 5 miles west of the Southwestern Gas Company's well and as the evidence for such an igneous body is very strong, it may well be that the Silver City intrusion and the Rose dome granite porphyry are parts of the same intrusion and if this has considerable deep underground eastward extension a dike or sheet need not have gone far from the parent body.

The nature of the igneous body of which the black rock may be an apophysis must be left unsettled, but the view of its being a dike is favored and it is suggested that the contact metamorphic minerals and black rocks of the Lieurance well, the basic igneous rocks of the Southwestern Gas Company's well, and the metamorphic rocks of Silver City are all manifestations of the intrusion of a large igneous body into the Pennsylvanian and older sediments at some date later than the deposition of the Pennsylvanian strata which now form the surface rocks of the region, and that the Rose dome granite porphyries represent the parent body and the black rocks minor intrusives therefrom.

Many wells have been drilled on, or adjacent to, the Rose dome and Silver City anticline. Some of these were in the old days when no sam-

[1]W. H. Twenhofel and E. C. Edwards, "The Metamorphic Rocks of Woodson County, Kansas," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 5 (1921), pp. 64-74.

ples were saved and thus the facts they might have yielded are lost. Some have been drilled in recent years with some samples saved, but no complete set of samples has come to the writers' attention. Some sets of samples of these recent wells may be stored away in the collections of the various petroleum companies. If such should be the case, the senior writer would greatly appreciate an opportunity to study such samples for the light they might give upon the nature and extent of the intrusives of this region. Particularly would he like to see a complete set of samples from the well in Section 24 in which the "dacite dike" was reported. It is probable that other wells will be drilled on, or in the vicinity of, the two structures. Such wells should be carefully sampled and the senior writer would greatly appreciate an opportunity to study the samples. If new wells are drilled in any direction for a distance of 4 or 5 miles from either of the two structures, the senior writer is desirous of being informed so that arrangements may be made to acquire samples to the end that more may be learned of the character and extent of the Rose and Silver City intrusives.

GEOLOGICAL NOTES

RAINBOW CITY FIELD, UNION COUNTY, ARKANSAS

Drilling activity late in 1927 in the Champagnolle district of northeastern Union County, Arkansas, which discovered a new pool of oil and gas, later named the Rainbow City field, has subsequently uncovered interesting geological conditions.

In this field are two producing horizons which according to our present understanding of the stratigraphy are in the Trinity group of the Comanche series (Lower Cretaceous). Owing to the character of the strata, which consist mainly of non-fossiliferous red clays and light-colored sands, it is difficult to recognize any definite horizon throughout the area.

The upper sand at about 2,900 feet in depth produces small quantities of oil of about 27° Bé. gravity and the lower sand at about 3,100 feet in depth, the principal horizon, produces oil of about 35° Bé. gravity.

A striking difference in conditions is shown between the Magnolia Petroleum Company's Carroll No. 1 well, in the SE. corner of SW. 1/4, NE. 1/4, Sec. 1, T. 14 S., R. 11 W., and the Ohio Oil Company's Crain No. 1 well, 330 feet south and 430 feet east of the center of Sec. 1, T. 14 S., R. 11 W. The Magnolia well produces 35° Bé. oil from a depth of 2,982 feet and the Ohio well 27° Bé. oil from a depth of 2,995 feet.

The marked difference in the character and gravity of the oil coming from approximately the same depths indicates faulted strata, but with the data available at this time, structural conditions are indeterminate.

On June 4, 1928, the daily production from the Rainbow City field was 34,301 barrels obtained from 16 wells located in Sections 1, 2, 10, 11, and 15, T. 14 S., R. 11 W.

The following analyses made by the Laboratory of the Kettle Creek Refining Company, El Dorado, Arkansas, indicate the character of the asphalt-base and the paraffin-base crude from practically the same subsea depth.

ANALYSIS OF PARAFFIN-BASE CRUDE, CHAMPAGNOLLE, ARKANSAS

Well: Magnolia Petroleum Company's Carroll No. 1.
Location: SE. corner, SW. ¼, NE. ¼, Sec. 1, T. 14 S., R. 11 W., Union County.
Date: November 22, 1927.
Subsea depth: 2,903 feet.

Gravity	34.0° A. P. I.
Bottom settling and water	0.6%
Sulphur	1.38%
Over at 122° F.	2.0 %
Viscosity at 100 S. U.	57
Pour	zero

Yield	*374 Hempel*		*410 Hempel*	
	Per Cent	*Degrees A.P.I.*	*Per Cent*	*Degrees A.P.I.*
Gasoline	28.0	63.3	31.8	61.6
Kerosene	20.6	42.0	13.4	41.9
Gas oil	7.4	33.2	10.0	33.1
Fuel oil	43.0	18.6	44.0	18.4

Quality

Gasoline	sweet
Kerosene	sour
Gas oil	45° F. pour
Fuel oil	55° F. pour; 1.51% sulphur 82 furol viscosity

Paraffin-base crude

ANALYSIS OF ASPHALT-BASE CRUDE, CHAMPAGNOLLE, ARKANSAS

Well: Edwin M. Jones' Crain No. 2.
Location: SW. cor., NE. ¼, SE. ¼, Sec. 2, T. 14 S., R. 11 W., Union County.
Date: December 5, 1927.
Subsea depth: 2,900 feet.

Gravity	27.3° A. P. I.
Bottom settling and water	1.0%
Sulphur	
Over at 122° F.	1.5%
Viscosity at 100 S. U.	89
Pour	zero

Yield	*374 Hempel*		*410 Hempel*	
	Per Cent	*Degrees A.P.I.*	*Per Cent*	*Degrees A.P.I.*
Gasoline	24.5	57.9	27.4	55.5
Kerosene	....	....	....	....
Gas oil	20.2	32.6	17.0	32.1
Fuel oil	54.3	16.1	54.6	16.3

Quality

Gasoline	sweet
Kerosene	———
Gas oil	zero pour
Fuel oil	zero pour 121 furol viscosity

Asphalt-base crude

W. C. SPOONER

SHREVEPORT, LOUISIANA
June, 1928

PRODUCTION IN EAST CARROLL PARISH, LOUISIANA

A new field is believed to have been discovered with the completion of the Palmer Corporation's O'Brien No. 1 well in Sec. 7, T. 19 N., R. 11 E., East Carroll Parish, Louisiana. This well is capable of producing 51,000,000 cubic feet of gas per day from the Monroe gas rock—probably the equivalent of the Nacatoch sand and Ripley formation (Upper Cretaceous)—from a depth of 2,357 feet. The top of the producing sand was encountered at 2,346 feet. The well is 35 miles east of the Monroe and Richland gas fields and 17 miles west of Mississippi River.

An interesting feature of this area is the fact that geophysical instruments—magnetometer, seismograph, and torsion balance—indicated a pronounced structural feature, generally believed to be a body of igneous rock, probably at a moderate depth below the surface.

W. C. Spooner

Shreveport, Louisiana
June, 1928

DEEP-WELL TEMPERATURES IN OKLAHOMA

The work on deep-well temperatures, first undertaken a few years ago by the American Petroleum Institute, is being continued this year in three states, California, Texas, and Oklahoma. Heretofore the work in Oklahoma has been under the direction of H. C. George, head of the school of petroleum engineering of the University of Oklahoma, but on Professor George's recommendation, this work has been placed in charge of the writer. The local advisory committee at Norman consists of Professor George, V. E. Monnett, head of the school of geology, and William Schriever of the department of physics. The general committee which served last year, consisting of R. S. McFarland, president of the American Association of Petroleum Geologists, W. B. Wilson, chief geologist of the Gypsy Oil Company, and F. L. Aurin, chief geologist of the Marland Company, has been continued.

John A. McCutchin, graduate in geological engineering of the University of Oklahoma, has been selected as observer for the project. During the month of May, 1928, C. E. Van Orstrand, chief physicist of the U. S. Geological Survey, under whose general direction all the geothermal work is being carried forward, spent several weeks in the Healdton field of southern Oklahoma. Mr. McCutchin, who was with Dr. Van Orstrand at this time, learning the technique of the work, is already in the field and will spend at least one year on the project. Funds have

been allocated by the American Petroleum Institute for salary and expenses. The work is under the general direction of the Petroleum Committee of the National Research Council, of which K. C. Heald is chairman, and E. DeGolyer and David White are members.

Mr. McCutchin will report directly to Dr. Van Orstrand, who will tabulate and correlate the results. At the present time work will be carried on in the Healdton field, but later, wells in Cushing, Seminole, and other fields selected by the committee, will be tested.

We solicit the coöperation of the petroleum geologists of Oklahoma in this matter. It is obvious that only idle wells can be worked, and the preference is for wells which have ceased to produce and are about to be abandoned, and which have not been disturbed for a week or more. In many cases, however, it may be possible to take the temperature of new wells at the time when the cement is setting.

Geologists who know of wells in Oklahoma which might be investigated will greatly assist in this work if they will notify Mr. McCutchin or the writer.

CHARLES N. GOULD

OKLAHOMA GEOGRAPHICAL SURVEY
NORMAN, OKLAHOMA
June, 1928

DISCUSSION

LOSS OF RED COLOR OF ROCKS

Frequent observation has provided good evidence that for most cases of loss of red color in rocks of sedimentary origin, the color change is due to a reduction of the pigment, which is as a rule ferric oxide, to a ferrous state. This reduction may be followed by solution of the iron and its removal, but this process is not necessary to the color change. In many cases such loss in color has been ascribed to a poorly understood reducing action of humic acid, which may be questioned.

In a recent geologic note in the *Bulletin*, Lon D. Cartwright, Jr.,[1] described a very interesting case of the loss of color of Red-bed boulders after their deposition along the beach near Pintas Point, California. A note of explanation refers to a paper by Fred R. Neuman,[2] which in turn refers to a paper by John W. Gruner[3] for the chemical processes giving rise to the reduction of ferric compounds. In a list of conclusions Gruner[4] gives the following:

1. Solutions from decaying plants dissolve all oxides and carbonates of iron, and most of the silicates, but do not seem to attack pyrite appreciably.

3. One of the chief differences between natural organic solutions and carbonic acid is that the organic solutions reduce ferric iron compounds to soluble ferrous salts, while carbonic acid does not.

In a later section of the report, in his conclusions regarding the precipitation of iron from organic solutions, Gruner[5] says:

1. In the presence of air, iron is precipitated exceedingly slowly, if at all.

5. At low temperature organic matter alone does not reduce ferrous or ferric salts to iron sulfid. Bacteria seem to be necessary.

The bacteria mentioned in the discussion of this type of action are those characterized by their activity in reducing sulphates to hydrogen sulphide. Possibly the doubtful precipitation of iron from solutions which have air in contact is due to an oxidation of the hydrogen sulphide (by oxygen from the air) as fast as it forms. Certainly, it appears that the presence of hydrogen sulphide, and not the bacteria which cause its generation, is required to cause

[1]Lon D. Cartwright, Jr.,' 'Loss of Color of Red Sandstone upon Re-deposition," *Bull. Amer. Assoc. Petrol. Geol.*, Vol. 12, No. 1 (January, 1928), pp. 85-87.

[2]Fred R. Neuman, "Cretaceous White Clays of South Carolina, *Economic Geology*, Vol. 22 (1927), pp. 383-84.

[3]John W. Gruner, "Origin of Sedimentary Iron Formations," *Economic Geology*, Vol. 17 (1922), pp. 408-59.

[4]John W. Gruner, *op. cit.*, p. 435.

[5]*Op. cit.*, pp. 444-45.

iron sulphide precipitation, for the reaction is easily obtained in the laboratory by use of hydrogen sulphide from any convenient source.

Hydrogen sulphide is commonly present in any decaying organic matter in moderate amounts, and noticeably so in substances with important amounts of sulphur compounds. This association of decaying matter and hydrogen sulphide is so common that most of us remember one of its most prominent characteristics as a "rotten" odor. Does it not seem within the realm of possibility that the "solutions from decaying plants" used by Gruner in his experiments developed some hydrogen sulphide? Certainly its presence would help to explain the reducing action of such organic solutions on ferric oxide and the failure of carbonic acid to produce the same reaction.

The composition and character of soils in tropical areas with luxurious vegetation and heavy rainfall should clearly show the potency of decaying organic material, as such, to cause the reduction of ferric oxide. The time available in such areas for the removal of ferric compounds should have been ample to permit a practical completion of any reducing process, and the amount of organic acids resulting from the decay of plant matter should have been sufficient. Shantz and Marbut,[1] however, give soil analyses which show the presence of ferric iron compounds in considerable abundance, although the soils are mainly well weathered and thoroughly leached. The following four partial analyses are taken from the thirty-one analyses in the work of Shantz and Marbut, and only the determinations of iron are given. The analysis numbers and descriptions are copied from the same source.

	IX	X	XI	XII
Fe_2O_3	7.05	7.53	7.52	8.32
FeO	....	....	....	....

IX. Sample collected by Shantz at a depth of 6 inches beneath a rich growth of bracken at Elizabethville, Belgian Congo. Analysis by Robinson and Holmes in laboratory of U. S. Bureau of Soils.

X. Same as IX, taken at a depth of 1 foot. Same analyst.

XI. Same as IX, taken at a depth of 24 inches. Analysis by Holmes in laboratory of U. S. Bureau of Soils.

XII. Same as XI, taken at a depth of 42 inches, same analyst.

From these analyses it is readily seen that, even under a rich growth of vegetation under tropical conditions, the amount of ferric iron present in the soil is rather large and varies too slightly to give support to the idea that solutions from decaying organic matter have caused any important reduction of ferric compounds. All of the other soil analyses given by Shantz and Marbut seem to corroborate the suggestion that organic acids do not reduce ferric oxides, but that, in cases for which apparent reductions have been reported from such causes, hydrogen sulphide was probably present and responsible for the chemical change.

Unless the character of the decaying organisms along the coast in California is very different from that of the organisms commonly found along the

[1] H. L. Shantz and C. F. Marbut, "The Vegetation and Soils of Africa," *American Geographical Society Research Series No. 13* (1923), pp. 218-21.

Atlantic coast, there should be ample hydrogen sulphide to cause the reduction of ferric oxide. In summer, along some parts of the Atlantic coast, there is so much hydrogen sulphide in the shallow water that the unpleasant odor is objectionably strong, and white lead paint on boats turns dark.[1] Unquestionably, for that territory, there is no reason for looking further than to hydrogen sulphide for the agent causing any chemical reductions of mineral matter in and near the shoal shore waters.

Red-bed bleaching can easily be accomplished by the action of a solution of hydrogen sulphide gas in water, as anyone interested may prove after a few minutes' work in a laboratory. Why, then, should we refer Red-bed bleaching as observed by Cartwright on the Pacific coast to reducing action caused by weak reducing agents such as "organic acid" when a very potent agent, hydrogen sulphide, is probably present? The possibility of reduction of iron oxides by hydrogen sulphide is demonstrable beyond a doubt. For all examples of ferric oxide reduction under circumstances which admit the possibility of the presence of hydrogen sulphide, this should be given consideration in preference to other reducing agents which occur under natural conditions.

GAIL F. MOULTON

URBANA, ILLINOIS
May, 1928

FAULTING IN THOMAS FIELD, KAY COUNTY, OKLAHOMA

A paper entitled "Steep Subsurface Folds versus Faults," by Charles T. Kirk and T. E. Weirich, which was published in the December, 1927, Bulletin of the Geological Society of America, is of particular interest to me, since the paper resolves itself primarily into an attack upon my interpretation of the subsurface structure of the Thomas pool, as set forth in my paper entitled "Thomas Oil Field, Kay County, Oklahoma," published in the *Bulletin* of the A. A. P. G., Vol. 10, No. 7 (July, 1926), pp. 643-55.

The authors present two cross sections, using the identical wells used in the two sections which were incorporated in my original paper. Their sections, however, are drawn to the same vertical and horizontal scale, whereas in mine the vertical scale was twice the horizontal scale. Their argument is that this exaggeration of the vertical scale is responsible for all the apparent evidence of faulting and that their "undistorted" cross section clearly show the fallacies of my interpretation.

There can be no quarrel with an honest difference of opinion based on accepted facts. Consequently, if the authors had confined themselves strictly to the facts in presenting their case, there would be no occasion for further discussion, since my interpretation of the pre-Pennsylvanian structure as faulting rather than folding, together with the evidence on which it was based, was incorporated in my original paper. The evidence of faulting was admittedly indirect evidence, but was presented with a scrupulous regard for accuracy.

However, since there are some errors of fact in their presentation of their case, it seems desirable to undertake a further discussion of the subject, (1) for

[1]A. N. Murray, personal communication.

the purpose of pointing out the errors of their paper, and (2) for the purpose of presenting some additional avidence which is now available, of normal faulting on the north side of the field.

The most serious error in their paper is contained in their north-south cross section (Fig. 3). In it the position of the formations as plotted on the vertical line representing the Marland's Thomas No. 1A well, is higher than their true position by more than 100 feet. Raising these formations by that amount, at that location, gives the profile on the top of the Viola lime the appearance of a true dome. However, if the top of the Viola at this location be lowered to its actual position, that is, 6 feet lower than it is encountered in Marland's Thomas No. 4A, it at once becomes apparent that there is no appreciable flexure on the pre-Pennsylvanian strata between The Twin State's Siler No. 1 on the south and Marland's Thomas No. 4A on the north. Since the east-west profile also shows the top of the Viola as a straight line from Marland's Thomas No. 1A, through Marland's School Land No. 1A, to Marland's School Land No. 7, it is evident that the portion of the strata controlled by these wells is geometrically a plane rather than a warped surface. In other words, there is evidence of a tilting of this segment of rocks, but none whatever of its folding. The relation of the vertical and horizontal scale in the cross sections has no bearing whatsoever upon this fundamental fact.

The error in plotting previously referred to seems particularly unfortunate in view of the fact that the same well also appears in their east-west cross section (Fig. 2), where the formations are plotted in their true positions. Extending the minus 3,000-foot line across the two figures makes the discrepancy apparent at once. Scaling from this line the discrepancy amounts to 125 feet.

The "serrated topography" which they postulate as the explanation for the abrupt increase in the thickness of the Cherokee shale between Marland's Thomas No. 2 and Carter's Thomas No. 1 is an arbitrary assumption, unsupported by evidence, either in this field or in the surrounding area. The Tonkawa field will serve to illustrate the point. In that field a much larger area of "Wilcox" sand production has been completely developed. But cross sections through the field invariably show the profile of the contact of the Pennsylvanian and the pre-Pennsylvanian as a remarkably smooth curve, except where these cross sections cross the fault which marks the boundary of the field on the northeast. At that point they all show an abrupt increase in the Cherokee shale interval exactly as in the Thomas field. Therefore, if the existence of the Tonkawa fault be admitted, the behavior of the Cherokee shale interval and of the profile of the contact of the Pennsylvanian and the pre-Pennsylvanian in the Thomas field must be considered as valid evidence of the existence of a similar fault scarp in the latter area.

The authors introduce mechanical arguments in an attempt to prove that the presence of this fault scarp in the pre-Pennsylvanian would necessitate faulting of the Pennsylvanian and Permian. But the abrupt increase in the Cherokee interval is not disputed and it must be evident to even a casual student of the situation that the postulation of faulting does not necessarily demand that the subsequently eroded fault scarp shall be inclined at an angle of more than 35° from horizontal. In my original diagrams the fault planes were drawn vertically, expressly to avoid conveying the impression that there

was then any evidence to indicate whether the faults were normal or thrust faults. However, if this structural feature was the result of a vertically-acting force, the logical assumption is that faulting in the sedimentary rocks would be normal faulting at an angle of about 45° (the approximate angle of the maximum shearing stresses developed in those rocks) and erosion might readily reduce this angle in the fault scarp by another 10°.

On the other hand, they offer no explanation for the system of mechanics by which they propose to throw all the flexure between a uniform dip of 11° on one flank, and their postulated uniform dip of 25° on the opposite flank, into the space between two wells approximately 700 feet apart without producing an enormous fissure, although the series of sediments involved is made up almost entirely of dolomite, limestone, and sandstone and was presumably more than 2,000 feet thick.

In discussing the occurrence of sulphur water in Marland's Thomas No. 5, they state (p. 587):

> Siliceous lime is known to be in juxtaposition with the overlying Pennsylvanian rocks by unconformable contact in the Retta field, 8 miles distant—and in other fields to the north. It therefore appears quite possible that the sulphurous water may have migrated laterally this short distance from the Retta field or other known or unknown overlap contacts.

The first part of the quoted statement must be classified as a misinterpretation of the facts, for no well drilled in the Retta field has found the "Siliceous lime" in contact with the Pennsylvanian. The last part seems to be an attempt to avoid the obvious inference that a copious flow of water of any sort from the extremely dense "Black lime" of the Mississippian probably indicates fracturing, since neither on the flanks of the Retta field, nor elsewhere in this general area, is water ordinarily found at that horizon.

Again in their paper (p. 585) this statement occurs: "It is an uncommon assumption that *heavily loaded* rocks, whether shale or the more brittle limestone, must fault before assuming an inclination of 25°." Aside from the fact that I made no such generalization, my statement being, "The brittle character of the rocks involved (principally limestones and sandstone) makes it almost inconceivable that a dome of such small area could have been elevated to such a height (1,000 feet) without faulting," their implication that the rocks involved were *heavily loaded* at the time this elevation took place is unfounded. On the contrary, the evidence indicates that the "Mississippi lime" was exposed at the surface.

The foregoing examples will suffice to indicate the character of the methods adopted to bolster up their attack on my interpretation of the structure of this area.

Before concluding, however, I wish to point out the direct evidence which is now available, of normal faulting on the north flank of this structural feature. Two wells in this field have been deepened to the "Siliceous lime." Both are relatively high on the structure and there is a difference of approximately only 30 feet in the datum elevations at which they encountered the top of the "White lime."

One of the wells, Marland's School Land 24, No. 1A, had almost exactly the predicted normal thickness (300 feet) of Simpson between the "White

lime" and the "Siliceous lime," the actual thickness being 296 feet. The other well, Marland's Thomas No. 6, encountered only 107 feet of Simpson between the same markers. There are only two possible explanations for this discrepancy: (1) that Thomas No. 6 drilled through the fault plane of a normal fault somewhere in the Simpson formation, or (2) that uplift occurred during Simpson time.

The second possibility is practically precluded by the fact that School Land 24, well No. 1A shows no thinning whatever in comparison with the normal Simpson section, though it is practically as close to the crest of the structure as is Thomas No. 6. The improbability of such a cause for this discrepancy in the Simpson thickness is further emphasized by the fact that none of the major anticlines in this immediate area afford any evidence of uplift during Simpson time.

The conclusion seems inescapable that this abrupt shortening of the Simpson interval is due to the presence of a normal fault with a vertical throw of approximately 190 feet. Moreover, this interpretation fits well with the present structural relations between this well (Thomas No. 6) and the well on the next location south (Marland's Thomas No. 3). The actual top of the "Wilcox" sand was encountered in the former well at a point 155 feet lower than the point at which the eroded surface of the same sand was found in the latter. In order to place the pre-Pennsylvanian strata at the same elevation in these two wells, prior to this faulting, it is only necessary to assume that the known erosion of the "Wilcox" sand in Thomas No. 3 resulted in the removal of the upper 35 feet of that formation. This estimate appears not at all unreasonable in the light of any other known facts concerning this area.

From this evidence it would appear that my original paper was slightly in error as to the location of the fault on the north side of the field, although it may easily be true that this is only the first of a series of fractures, but that the interpretation of the evidence then available as indicative of faulting rather than folding was entirely correct.

S. K. Clark

Ponca City, Oklahoma
May 11, 1928

REVIEWS AND NEW PUBLICATIONS

"Anticlines of the State of Iowa." By GLENN S. DILLÉ, *Proc. Iowa Academy of Science*, Vol. 33 (1926), pp. 183-98.

The geology of Iowa has been thoroughly studied during the past fifty years, reports having been completed by the Iowa Geological Survey on all of the 98 counties of the state. Most of these have been published, but many of the volumes are out of print and available only in libraries, while even though the reports be at hand the labor of reading nearly one hundred separate volumes is rather discouraging to one who may be in search of information regarding local folding.

In this paper Mr. Dillé has presented the results of careful search of all available literature, listing and briefly discussing, by counties, the known or reported anticlines within the state. Conflicting accounts have been given of many of these folds, and the discrepancies are noted but no attempt made to pass judgment.

Iowa at present is not considered attractive for prospecting, but, should the geologist be called upon to do work there, the report by Mr. Dillé will be found helpful in indicating localities where local folding is known to occur. A limited number of copies is available for distribution by the author, Mr. Glenn S. Dillé, Department of Geology, S. U. I., Iowa City, Iowa.

J. V. HOWELL

PONCA CITY, OKLAHOMA
May, 1928

Die Gewinnung von Erdöl mit besonderer Berücksichtigung der bergmännischen Gewinnung (Production of Oil, particularly by Underground Mining). By GOTTFRIED SCHNEIDERS. Julius Springer, Berlin, 1927. 363 pp., 295 illus. Price, 32 M.

This book is very important for the technology of underground mining of oil, which method of recovery has a great future in the oil industry.

In an introductory manner the author speaks of origin of oil, petroleum geology, and present methods of drilling and producing oil. As one of the possible sources of oil, he mentions insects, which die in very large numbers. The book contains interesting remarks on Japanese oil fields, but on American conditions the author is only partly versed. Seven years as the average life of oil wells in Texas and Louisiana is much too low. A remark that outcrops are scarce in the Appalachian and Mid-Continent fields could have been corrected after studying only a few of the numerous publications on these areas.

In the main part of the book all the details of general mining practice used or useful in oil mining are described at great length. Methods suggested by Ehrat, Ranney, and Rich are hardly mentioned. Of particular interest are

chapters on oil left in the sand after ordinary producing methods have been applied, on ventilation, lighting and safety appliances, and on the extraction of oil from the oil-containing rock, after it is mined. In a final chapter, the author states that oil mines, which furnish 11 tons of seepage oil to the meter of gallery, as at Pechelbronn, are bound to be big paying propositions. Under European conditions the limit would be at about 2 tons to the meter. Where most of the oil has to be produced by mining the oil-containing rock and extracting the oil, conditions are less favorable. When most of the mining is done by manual labor and a miner gets $1.50 a day and the oil is worth about $3.00 a barrel, then the excavated rock must contain from 10 to 17 per cent of recoverable oil (depending on hardness of rock, etc.), to pay for the operation. Where the cost of labor is high, as in the United States, it will be necessary to use mechanical means extensively.

The value of the book is greatly enhanced by 295 illustrations.

EDWARD BLOESCH

TULSA, OKLAHOMA
May, 1928

"Aufgaben und Arbeitsweisen der Ölgeologie (Problems and Methods of Petroleum Geology)." By HANS HLAUSCHEK. Band 14 der *Abhandlungen zur praktischen Geologie und Bergwirtschaftslehre*, von Georg Berg. Published by Wilhelm Knapp, Halle (Saale), 1928, 112 pp., 32 figures. Price, 8 M.

This book gives the reader who is not acquainted with the problems and methods of petroleum geology, a very good introduction to this subject, dealing also with the latest methods in use. It neglects more generally known subjects, such as mapping in the field, but emphasizes specialized methods, which are in part of a chemical or technical character.

The first chapter describes the geologist's work in the field, the significance of oil, and diamond core-drilling in areas without workable outcrops. Instead of diamonds the author prefers "volomit," a wolframcarbide, for soft and medium-hard beds. This abrasive works practically as fast as diamonds and is much cheaper. The first chapter also discusses the geophysical methods of the magnetometer, the torsion balance, the electroscope (for measuring the action of a higher radioactivity of rocks on gas along faults), the seismograph, and the method with electric currents. For areas of the type of the Appalachian and Mid-Continent regions the author claims the inductive method of Sundberg is of great value, as it gives direct data on the structure of the first horizon having good conduction, which would be the first salt-water horizon below the surface.

The second chapter deals with well locations, drilling methods, well samples and records, with the work and study connected with subsurface water encountered by drilling wells, with the measuring of quantity and quality of oil and gas in a producing well, and with the making of a production curve of a well.

The study of an oil field by means of subsurface maps and cross sections comprises the third chapter.

The fourth and last chapter takes up the study of water problems in oil fields, briefly discussing water analysis and the different interpretations of its results by means of graphical methods. The physical conditions in an oil horizon are described, with emphasis on the great value of saving the gas pressure in an oil well. An outline is given of all the different methods for the recovery of oil, such as pumping, the Smith-Dunn process, air-gas lift, and flooding. The book concludes with a general introduction to valuation methods on oil wells and oil land.

As the book describes mainly American methods in solving the problems of petroleum geology, its content will be mostly familiar to the American geologist, but it will surely be of great value for anyone having a fundamental knowledge of geology and desiring to get acquainted in a general way with the methods and problems of present-day oil geology. A list of 67 publications, mostly American, increases the value of the book.

GERHARD G. SENFTLEBEN

TULSA, OKLAHOMA
May 31, 1928

RECENT PUBLICATIONS

GENERAL

"Tabulated Analyses of Representative Crude Petroleums in the United States," by N. A. C. Smith and E. C. Lane. *U. S. Bureau of Mines Bulletin 291*. Superintendent of Documents, Government Printing Office, Washington, D. C. Price, $0.15.

The Earth Upsets, by Chase Salmon Osborn. Waverly Press, Inc., Baltimore, Maryland, 1927. A non-technical book on the earth's motion. Price, $3.00.

The Geology of Petroleum and Natural Gas, by Ernest Raymond Lilley. D. Van Nostrand Company, Inc., 8 Warren Street, New York, N. Y., 1928. 524 pp. Cloth. 6 x 9 inches. Illustrated. Price, $6.00.

Oil Field Exploration and Development, by A. Beeby Thompson. D. Van Nostrand Company, Inc., New York. 2 vols. Cloth. 6¼ x 9¾ inches. Illustrated. Now available at $20.00 per set.

Undeveloped Mineral Resources of the South, by Henry Mace Payne. The American Mining Congress, Washington, D. C. 368 pp. Cloth. Price, $5.00.

Der Bewegungsmechanismus der Erde, by Rudolf Staub. Gebrüder Borntraeger, Schöneberger Ufer 12a, Berlin, W. 35. 1928. 270 pp., map, and 44 figures. 7 x 10¼ inches. Paper. Price, 18 M.

Foraminifera, Their Classification and Economic Use, by Joseph A. Cushman. Cushman Laboratory for Foraminiferal Research, Sharon, Massachusetts. Approx. 400 pp. Cloth. Price, $5.00, postpaid.

ILLINOIS

The following publications may be obtained from the State Geological Survey, Urbana, Illinois:

"The Oil and Gas Resources of the Ava-Campbell Hill Area," by Towner B. Root. *Report of Investigations 16*. Price, $0.50.

"Geology and Economic Resources of the St. Peter Sandstone in Illinois," by J. E. Lamar. *Bulletin 53.* 175 pp., 46 illus. Price, $1.00.

"A Study of the Core of the Yanaway Well No. 33 in the Siggins Pool in Northeastern Cumberland County," by J. E. Lamar. "Corrosion in the Eastern Illinois Oil Fields," by J. E. Lamar and C. R. Clark. *Illinois Petroleum 15.* Price, $0.25.

MEXICO

"New Vicksburg (Oligocene) Mollusks from Mexico," by C. Wythe Cooke. *No. 2731, Proceedings of the U. S. National Museum,* Vol. 73, Art. 10, pp. 1-11, plates 1, 2. Washington, D. C., 1928.

MISSISSIPPI

"Recent Oil and Gas Prospecting in Mississippi with a Brief Study of Subsurface Geology," by Ralph E. Grim. *Bulletin 21, Mississippi State Geological Survey,* University, Mississippi, 1928. Report on petroleum prospecting supplementary to the ninth biennial report of January, 1924. Director E. N. Lowe calls attention to the fact that Mississippi is in the producing class of states so far as concerns natural gas. 98 pp., 4 figures.

OHIO

"Mineral Industries of Ohio: I, Map Showing Location of Industries, II Directory of Producing Firms," by J. A. Bownocker and W. Stout. *Fourth Series, Bulletin 3, Geological Survey of Ohio,* Columbus, 1928. Contains list of petroleum and natural gas operators. 94 pp.

THE ASSOCIATION LIBRARY

Headquarters acknowledges library accessions:

CALIFORNIA

From G. Dallas Hanna:
"Cretaceous Diatoms from California"
"Geology of West Mexican Islands"

GENERAL

From C. A. Heiland:
"Suggestions for the Improvement of Pendulum Observations"
"Note on Activities in Atmospheric-Electric Investigations," by W. F. G. Swann
"Report upon the Organization of the Department of Geophysics at the Colorado School of Mines, Golden, Colorado"
"A Cartographic Correction for the Eötvös Torsion Balance"

THE ASSOCIATION ROUND TABLE

FOURTEENTH ANNUAL MEETING AT FORT WORTH, TEXAS, MARCH 21, 22, AND 23, 1929

The executive committee takes pleasure in announcing that the fourteenth annual meeting of the Association will be held in Fort Worth, Texas, March 21, 22, and 23, 1929, at the invitation of the Fort Worth geologists. More detailed information and plans for the program will be published later.

As more members of the Association reside in Texas than in any other state and as Fort Worth is centrally situated and easily accessible to the majority of our members it is probable that the attendance at the convention next year will set a record.

MEMBERSHIP APPLICATIONS APPROVED FOR PUBLICATION

The Executive Committee has approved for publication the names of the following applicants for membership in the Association. This does not constitute an election, but places the names before the membership at large. In case any member has information bearing on the qualifications of these applicants, please send it promptly to J. P. D. Hull, Business Manager, Box 1852, Tulsa, Oklahoma. (Names of sponsors are placed beneath the name of each applicant.)

FOR ACTIVE MEMBERSHIP

Herbert Aid, Fort Worth, Tex.
H. B. Fuqua, B. E. Thompson, H. M. Bayer

C. Dwight Avery, Washington, D. C.
John S. Ivy, W. T. Thom, Jr., Hugh D. Miser

Harvey Bassler, Iquitos, Amazon River, Peru, S. A.
E. W. Shaw, E. N. McCormack, J. P. D. Hull

Bernard Rosenthal, Canton, Mo.
Walter W. Larsh, S. Morse Willis, M. M. Valerius

Hubert G. Schenck, Stanford University, Calif.
Thomas L. Bailey, William S. W. Kew, Frank S. Hudson

Rodolphe Schider, Miri, Sarawak, Borneo
E. F. Davis, Roy R. Morse, John G. Burtt

John Vincent Terrill, Amarillo, Tex.
H. M. Bayer, B. E. Thompson, H. B. Fuqua

Dwight Gregory Vedder, Los Angeles, Calif.
Guy L. Goodwin, F. C. Merritt, J. E. Elliott

FOR ASSOCIATE MEMBERSHIP

Robert B. Cheney, Norman, Okla.
Charles E. Decker, V. E. Monnett, A. J. Williams
John W. Brice, McCamey, Tex.
Wallace E. Pratt, E. Holman, F. L. Whitney
George H. Harrington, Tulsa, Okla.
T. E. Weirich, Paul Ruedemann, G. C. Potter
Walter Kauenhowen, Houston, Tex.
Donald C. Barton, W. T. Thom, Jr., Paul Weaver
Eugene A. Murchison, Jr., McCamey, Tex.
Wallace E. Pratt, E. Holman, F. L. Whitney
Vladimir P. Pentegoff, Golden, Colo.
J. Harlan Johnson, John H. Wilson, F. M. Van Tuyl
Albert W. Sands, Santa Paula, Calif.
William S. W. Kew, Irvine E. Stewart, Vernon L. King
Harry Charles Spoor, Jr., Shreveport, La.
Gail F. Moulton, John S. Ivy, J. Y. Snyder
Lawrence L. Tabor, Barranquilla, Colombia, S. A.
N. L. Taliaferro, Henry J. Hawley, Charles W. Fowler, Jr.
Emmett P. Tatum, Jr., Shreveport, La.
Henry V. Howe, A. F. Crider, Elmer H. Finch
Henry Bayard Taylor, Fort Collins, Colo.
C. R. McCollom, Wallace E. Pratt, F. M. Van Tuyl
George Elmer Wagoner, Colorado Springs, Colo.
J. Harlan Johnson, Quentin D. Singewald, F. M. Van Tuyl
Jackson S. Young, Bartlesville, Okla.
Gail F. Moulton, Grant W. Spangler, John M. Nisbet

FOR TRANSFER TO ACTIVE MEMBERSHIP

Q. A. Abadilla, Manila, P. I.
S. W. Lesniak, M. N. Bramlette, C. A. Baird
Albert L. Ackers, Midland, Tex.
J. W. Beede, Hal P. Bybee, J. F. Hosterman
David Ainsworth, Wichita, Kan.
C. R. Thomas, J. S. Barwick, William L. Ainsworth
Charles R. Bickel, Marland, Okla.
G. R. Henson, R. B. Roark, Fanny C. Edson
George H. Doane, Los Angeles, Calif.
Edwin A. McKanna, N. A. Rousselot, C. R. McCollom
Paul A. Grant, Fort Worth, Tex.
Ben C. Belt, Roy T. Hazzard, B. E. Thompson
Schuyler B. Henry, Maracaibo, Venezuela, S. A.
Leonard W. Orynski, Graham B. Moody, S. H. Gester
Wilson Keyes, San Angelo, Tex.
J. W. Beede, J. F. Hosterman, V. E. Cottingham
Elmer A. Markley, Tulsa, Okla.
D. R. Snow, Robert H. Wood, Virgil O. Wood

George W. Schneider, Shreveport, La.
F. J. Miller, A. F. Crider, W. C. Spooner
Maurice D. Scruggs, Ponca City, Okla.
Glenn C. Clark, S. K. Clark, C. L. Arnett
Merritt B. Smith, Cartagena, Colombia, S. A.
Oliver B. Hopkins, Roswell H. Johnson, R. E. Somers
George D. Thomas, Shreveport, La.
Chester C. Clark, W. C. Spooner, Merle C. Israelsky
William Allen Watkins, Buenos Aires, Argentina, S. A.
V. E. Monnett, C. E. Decker, G. E. Anderson

EXECUTIVE COMMITTEE AT TULSA, JUNE 4

The first executive committee meeting of the present officers of the Association was held at headquarters, 504 Tulsa Building, Tulsa, Oklahoma, on June 4. Members present were president R. S. McFarland of Tulsa, first vice-president J. E. Elliott of Los Angeles, California, second vice-president in charge of finances David Donoghue of Fort Worth, Texas, and third vice-president in charge of editorial work John L. Rich of Ottawa, Kansas.

The committee accepted the invitation of the Fort Worth geologists to hold the fourteenth annual meeting at Fort Worth, and set the time of meeting as March 21, 22, and 23, 1929.

The ballot committee, composed of W. W. Keeler and W. J. Sherry, reported that the constitutional amendments, recently submitted to the members by letter ballot, were carried by large majorities, according to the returns as follows:

Proposal 1.—For, 609; against, 69. Life membership provided for.

Proposal 2.—For, 667; against, 9. Fiscal year corresponds with calendar year.

Proposal 3.—For, 651; against, 29. Technical, as well as regional, sections provided for.

The constitution was declared amended in accordance with the foregoing vote.

In compliance with the action of the Association in annual business meeting in San Francisco, March 22, 1928, the by-laws were declared amended to provide for the payment of a fee of $300 for life membership. These amendments, together with others passed during the previous year, are incorporated in the constitution and by-laws as printed in this number of the *Bulletin*.

The committee inspected the headquarters office facilities and decided to provide additional equipment to meet the needs of the growing organization. It was decided to bond the business manager and the second vice-president in charge of finances for $25,000 each.

President McFarland announced the re-appointment of C. R. McCollom of Los Angeles to serve as chairman of the general business committee through the fourteenth annual meeting.

CONSTITUTION AND BY-LAWS

(Adopted 1918 and amended 1921, 1923, 1925, 1927, and 1928)

CONSTITUTION

ARTICLE I. NAME

This Association shall be called the "American Association of Petroleum Geologists."

ARTICLE II. OBJECT

The object of this Association is to promote the science of geology, especially as it relates to petroleum and natural gas; to promote the technology of petroleum and natural gas and improvements in the methods of winning these materials from the earth; to foster the spirit of scientific research amongst its members; to disseminate facts relating to the geology and technology of petroleum and natural gas; to maintain a high standard of professional conduct on the part of its members; and to protect the public from the work of inadequately trained and unscrupulous men posing as petroleum geologists.

ARTICLE III. MEMBERS

SECTION 1. Any person actively engaged in the work of petroleum geology or in research pertaining to petroleum geology or technology is eligible to active membership in the American Association of Petroleum Geologists, provided he is a graduate of an institution of collegiate standing, in which institution he has done his major work in geology, and in addition has had the equivalent of three years' field experience in petroleum geology; and provided further that in the case of an applicant for membership who has not had the required collegiate or university training, but whose standing in the profession is well recognized, he shall be admitted to membership when his application shall have been favorably and unanimously acted upon by the executive committee; and provided further that these requirements shall not be construed to exclude instructors and professors in recognized institutions of learning whose work is of such a character as in the opinion of the executive committee shall qualify them for membership.

The executive committee may grant life membership to active members who have paid their dues and are otherwise qualified.

SECTION 2. Any person having completed as much as thirty hours of geology (an hour shall here be interpreted as meaning as much as sixteen recitation or lecture periods of one hour each, or the equivalent in laboratory) in a reputable institution of collegiate or university standing, or who has done field work equivalent to this, shall be eligible to associate membership in the American Association of Petroleum Geologists, provided at the time of his application for membership he shall be engaged in geological studies in an institution of collegiate or university standing, or shall be engaged in geological work. The executive committee shall advance from associate to active membership those associates who have, subsequent to election, fulfilled the requirements for active membership without the formality of application for such change.

SECTION 3. Active and associate members shall be elected to the Association according to the qualifications outlined in Sections 1 and 2, provided that the applicant properly fills out the regular application blank, including the signatures of *three* active members of the Association, and that such application be approved by at least three of the members of the executive committee of the Association, as provided for in Article IV, Sections 1 and 4.

SECTION 4. Associate members shall enjoy all privileges of membership in the Association, save that they shall not hold office, sign applications for membership, or vote in business meetings; neither shall they have the privilege of advertising their associate membership in the Association in professional cards, nor shall they have the privilege of signing professional reports as associate members of the Association.

SECTION 5. Each applicant for membership shall formally be notified in writing by the secretary of his election, and shall be furnished with a membership card for the current year, and until such formal notice and card are received, he shall in no way be considered a member of the Association.

SECTION 6. Applications for membership may be accepted at any time, but unless an applicant shall have his application approved and have been formally notified by the secretary of his election at least one month before the annual meeting, he shall not be allowed to participate in the business of said annual meeting.

SECTION 7. The executive committee may from time to time elect as honorary members persons who have contributed distinguished service to the cause of petroleum geology. Honorary members shall not be required to pay dues, nor shall they be allowed to vote.

ARTICLE IV. OFFICERS

SECTION 1. The officers of the Association shall consist of a president, a first vice-president, a second vice-president in charge of finances, and a third vice-president in charge of editorial work. These, together with the retiring president, shall constitute the executive committee and managers of the Association.

SECTION 2. The officers shall be elected annually from the Association at large by written ballot deposited in a locked ballot box by those active members present at the annual meeting, who have paid their current dues and are otherwise qualified under the constitution.

SECTION 3. No man shall hold the office of president or vice-president for more than two years in succession.

SECTION 4. The executive committee shall consider all nominations for membership and pass on the qualifications of the applicant; shall have the control of the Association's work and property; shall determine the manner of publication, and pass on all materials presented for publication; and may call special meetings when and where thought advisable, and arrange for the affairs of the same.

SECTION 5. The officers elect shall assume the duties of their respective offices one month after date of election.

SECTION 6. The fiscal year of the Association shall correspond with the calendar year.

ARTICLE V. MEETINGS

The annual meetings shall be held at a time most convenient for the majority of the members at a place designated by the executive committee. At this meeting the election of members shall be announced, the proceedings of the preceding meeting be read, all Association business transacted, scientific papers read and discussed, and officers for the ensuing year shall be elected.

ARTICLE VI. AMENDMENTS

This constitution may be amended at any time, provided that such amendment is proposed and signed by at least five members of the Association, and is presented and discussed at any annual meeting of the Association. The secretary shall take a ballot of the membership by mail within thirty days after the meeting of the Association, and a majority vote of the ballots received shall be sufficient to amend, provided more than one-half of the members return ballots.

ARTICLE VII. PUBLICATION

The proceedings of the annual meeting and the papers read shall be published in the annual bulletin. This shall be under the immediate supervision of the vice-president in charge of editorial work, assisted by associate editors whom he shall appoint in the various regions.

ARTICLE VIII. SECTIONS

SECTION 1. Regional and technical sections of the Association may be established, provided the members of such sections shall perfect an organization and make application to the executive committee, who shall submit the application to a vote at a regular annual meeting, a vote of two-thirds of the members present being necessary for the establishment of such a section; and provided that the Association may revoke the charter of any section by a vote of two-thirds of the membership.

BY-LAWS

SECTION 1. *Dues.*—The regular annual dues of an active member of the Association shall be $15.00. The annual dues of an associate member of the Association shall be $10.00. The annual dues are to be paid to the Association on or about January first for the year ending the following December.

The fee required for life membership shall be $300 payable in advance. Life membership fees shall become a permanent investment, the income from which shall be devoted to the same purposes as the regular dues.

SECTION 2. Any member who shall fail to pay his regular annual dues for a period of one year may be dropped from membership by a vote of the executive committee, but may later apply for membership under the regular rules, if desired.

SECTION 3. The payment of the annual dues entitles the member to receive, without further charge, one copy of the proceedings of the Association for that year.

SECTION 4. Any member who shall be guilty of flagrant violation of the established principles of professional ethics may, upon the unanimous vote of the executive committee, be suspended or expelled from membership, provided

that such person shall before suspension or expulsion be granted a hearing before the executive committee.

SECTION 5. District representatives to act as a council for the Association and as an advisory board to the executive committee shall be elected by the members of the several districts. Districts are to be designated by the executive committee. The number of each district's representatives on the general business committee shall be determined by the executive committee according to the number of active members residing in each district. Should any district fail to elect a representative, the president shall appoint such a representative at least thirty days before the annual meeting. The term of office of each representative shall commence with the first annual business meeting following his election, and shall be three years, excepting that one-third of those elected the first year of the adoption of this amendment shall serve for one year only, and one-third shall serve for two years only, thus providing that one-third of the representatives shall retire each year. The district representatives, together with the executive committee, shall constitute the general business committee which shall convene at the time of the annual meeting of the Association for the purpose of considering any business which may properly come before the Association, and of making recommendations for action by the Association. The chairman of the general business committee shall be appointed by the president at least sixty days before the annual meeting.

AMENDMENTS

These by-laws may be amended by a vote of three-fourths of the active members present at any annual meeting.

Memorial

CHARLES EDWIN WHITESIDE

Charles Edwin Whiteside died on November 12, 1927, from blood poisoning resulting from a slight nasal infection, after an illness of only three days. He is survived by his widow, a son, Richard Edwin, three years, and a daughter, Doris Lee, twenty months. At the time of his death, Mr. Whiteside was engaged in research work in the Los Angeles basin for the Marland Oil Company of California.

Mr. Whiteside was born in Prescott, Arizona, on April 2, 1897. He contemplated entering the university in 1917, but due to the World War he enlisted in the California National Guard on April 29, 1917. Later he was transferred to the 40th Division of the 160th Infantry. He served in France from July, 1918, until the armistice was signed, and returned to this country in the spring of 1919.

After returning to this country, Mr. Whiteside commenced oil field work with the Union Oil Company of California at Brea. In the fall of 1919 he entered the University of California, majoring in geology. During vacation periods he continued to work for the Union Oil Company at Brea and Richfield, California, and later for the Amalgamated Oil Company and the Federal Drilling Company at Santa Fé Springs, California. Mr. Whiteside was graduated from the University of California in the department of geology in 1923.

Shortly after leaving the university he was married to Miss Clare Elizabeth Smith. From 1923 to 1925 he was engaged in petroleum engineering for the Chancellor Canfield Midway Oil Company at Fellows, California. He entered the employ of the Marland Oil Company in 1925 as scout in the Coalinga district, and was transferred later to Bakersfield. In 1926 he was transferred to the valuation and research department where he carried on research work in the San Joaquin valley and the Los Angeles basin until his untimely death.

Mr. Whiteside proved to be a most conscientious and capable worker and was held in the highest regard by his associates. His sudden death has been a profound shock to all who knew him.

BRUCE SEYMOUR

LOS ANGELES, CALIFORNIA
May 3, 1928

AT HOME AND ABROAD

CURRENT NEWS AND PERSONAL ITEMS OF THE PROFESSION

PRESIDENT MCFARLAND has appointed five members to represent the Association on the American Committee of the World Engineering Congress to be held at Tokio, Japan, in October, 1929. The appointees are: HARRY R. JOHNSON, chairman; E. DEGOLYER, CHARLES J. HARES, FRED H. KAY, and C. R. MCCOLLOM.

The council of the Tulsa Geological Society has appointed a research committee to deal with problems of petroleum geology in the north Mid-Continent. One of its first efforts will be coöperation with the Kansas geologists in correlating formations along the Oklahoma-Kansas line. The committee is composed of FRANK C. GREENE, W. B. WILSON, LUTHER H. WHITE, FREDERICK A. BUSH, and ROBERT H. DOTT.

C. P. PARSONS had an article on "Accurate Estimate of Gas Reserves" in the *Oil and Gas Journal* of May 10.

B. B. COX has moved from Shreveport, Louisiana, to New York City. His address is care of C. Stuart Morgan, Room 417, 26 Broadway.

MARION H. FUNK resigned his position, May 15, as geologist with the Louisiana Oil Refining Corporation at Shreveport and is now geologist in charge of the geological department of the Pure Oil Company at El Dorado, Arkansas. Mr. Funk's territory includes Arkansas and northern Louisiana.

FRANK RINKER CLARK of the Mid-Kansas Oil and Gas Company, Petroleum Building, Tulsa, Oklahoma, spent a month in April and May in northern Mexico for the Ohio-Mexico Oil Corporation.

PAUL D. TORREY, geologist of the Northwestern Pennsylvania Producers Association, Bradford, Pennsylvania, wrote on "Geologic Factors in Water Flooding," J. E. EATON, consulting geologist, 628 Petroleum Securities Building, Los Angeles, California, wrote on "California Decline Last Half of 1928," and J. FRENCH ROBINSON, of the Peoples Natural Gas Company, Pittsburgh, Pennsylvania, wrote on "Deep Well Drilling in Eastern (Appalachian) Field," in the *Oil and Gas Journal* of May 17.

A party of Mid-Continent and Arkansas geologists under the auspices of the department of geology of the University of Arkansas, of which Albert W. Giles is head, studied part of the Pennsylvanian-Mississippian section in a two-day field trip near Fayetteville, Arkansas, May 12 and 13.

HERMAN J. OWEN, geologist of the Ohio Oil Company at Owensboro, Kentucky, has been engaged in reconnaissance of northern Mississippi and northwestern Alabama.

HANS E. THALMANN, of Cia. Mexicana Holandera "La Corona," S. A., at Tampico, Tamps., Mexico, returned to Switzerland in May to spend the summer with Mrs. Thalmann at their home, Mattenhofstr. 15, Bern.

JOSEPH H. SINCLAIR, geologist, 59 Wall Street, New York City, returned last April from an exploratory trip of five months in Ecuador under the auspices of the American Geographical Society.

J. E. ELLIOTT, vice-president of the American Association of Petroleum Geologists and president of the Elliott Core Drilling Company of Los Angeles, recently visited the Gulf Coast and the Mid-Continent in an airplane. Mr. Elliott and his pilot, "Pat" Farris, are educating their friends in the advantages of air travel for business and pleasure.

MRS. MARY VAUX WALCOTT, in memory of her husband, Charles Doolittle Walcott, has established a trust fund, accepted by the National Academy of Sciences, to provide for a bronze medal and honorarium to be given not oftener than once every five years for individual achievement in advancing knowledge of pre-Cambrian life and its history.

The Second International Conference on Bituminous Coal will be held in Pittsburgh, Pennsylvania, under the auspices of the Carnegie Institute of Technology, November 19 to 24. Members of the American Association of Petroleum Geologists are cordially invited to attend this conference and participate in the discussion. Charles R. Fettke, associate professor of geology and mineralogy, announces that recent developments in low temperature carbonization and other methods of processing coal to obtain petroleum substitutes that have been developed in Europe, will be emphasized. A large attendance of European scientists is assured. The conference therefore should be of considerable interest to petroleum geologists.

W. D. JOHNSTON, JR., has resigned his position as assistant professor of geology in the New Mexico School of Mines and as geologist in the State Bureau of Mines and Mineral Resources to accept an appointment with the groundwater division of the U. S. Geological Survey.

ROBERT F. IMBT, formerly chief geologist in the San Angelo district for the Pure Oil Company, resigned this position effective April 1 to associate himself with D. G. DUNBAR, formerly in charge of the Pure Oil Company office at San Angelo. Dunbar & Imbt will continue to make San Angelo their headquarters and will specialize in proven and semi-proven west Texas oil royalties.

CHESTER M. GARDINER has moved into new offices at 1013 California Petroleum Building, Los Angeles, California. His home address is University Club of Los Angeles, Box 1400, Station C.

MR. and MRS. STANLEY B. WHITE announce the birth of a daughter, Emily Jane, April 18, 1928, at Stuttgart, Arkansas. Mr. White is with the Transcontinental Oil Company.

LEON J. PEPPERBERG, geologist and engineer of Dallas, Texas, has accepted the position of consulting geologist for the Columbia Engineering & Management Corporation, which manages the Columbia System, including the Ohio Fuel Gas Company, United Fuel Gas Company, and several other subsidiaries. Mr. Pepperberg has moved his family to Columbus, Ohio, where his business address is 99 North Front Street.

E. G. WOODRUFF, 1611 South Detroit Street, Tulsa, Oklahoma, has returned from a trip of five months in Venezuela where he was engaged in geological exploration.

RICHARD A. JONES, geologist, has moved from Austin to Apt. 5, 320 East Dewey St., San Antonio, Texas. Mr. Jones published a paper on "Evidence for Recent Uplift on Gulf," in the *Oil and Gas Journal* of April 5.

A. F. MELCHER, 1137 North Cheyenne Avenue, Tulsa, Oklahoma, is the author of a paper, "Repressuring Oil Sands," in the *National Petroleum News* of May 16. This paper was read before the Mid-Continent Oil Scouts Association at Guthrie, Oklahoma, April 27.

LOUIS C. CHAPPUIS, formerly assistant chief geologist of Richfield Oil Company, is on the staff of A. E. STARKE, consulting geologist of Los Angeles, California.

E. RUSSELL LLOYD is associated with Fisher and Lowrie, 711 First National Bank Building, Denver, Colorado. In May Mr. Lloyd was situated in San Angelo, Texas.

DONALD C. BARTON, consulting geologist and geophysicist, Houston, Texas, gave a series of ten lectures on the applied geophysical methods in prospecting for oil, under the joint auspices of the departments of geology and of mining at Massachusetts Institute of Technology, incidental lectures on the economic geology and importance of salt domes before the department of geology, M. I. T., and before the departments of geology and of mining at Harvard University, and a lecture on geophysics before the Boston Geological Society.

At the annual meeting of the American Geophysical Union, March 26-27, in Washington, D. C., C. A. HEILAND, professor of geophysics, Colorado School of Mines, Golden, Colorado, gave a general paper on the applied geophysical methods in the symposium on applied geophysical methods, and DONALD C. BARTON gave papers on the Eötvös torsion-balance method in the symposium on applied geophysical methods and in the symposium on the determination of the figure of the earth.

CAREY CRONEIS has been appointed assistant professor of paleontological geology at the University of Chicago where he will have charge of the work in

invertebrate paleontology, succeeding in that field the late Professor Stuart Weller. Dr. Croneis is a graduate of Denison University, received his master's degree at the University of Kansas and for the past year has been instructor in geology at Harvard University and lecturer on paleontology at Wellesley College. He will conduct the field course in geology in Missouri this summer and begin his full time work in Chicago in October.

R. S. Rhoades, formerly of Denver, Colorado, is now at 1123 Security Building, Long Beach, California, with the Majestic Oil Corporation.

John M. Lovejoy has resigned as vice-president and director of the Amerada Petroleum Corporation of Tulsa, Oklahoma, to become president of a company formed in conjunction with the banking firm of W. A. Harriman & Company, Inc. Mr. Lovejoy's headquarters will be in the Harriman Building, 39 Broadway, New York City.

W. K. Knode, Jr., has moved from Eastland, Texas, to 1401 East Gold Avenue, Albuquerque, New Mexico, where he is engaged in consulting work.

Andrew C. Lawson, faculty member of the University of California for thirty-eight years and professor of geology for many years, has announced his retirement from university work.

W. W. Scott, recently with the Pure Oil Company as production engineer, is now with the Humble Oil & Refining Company at Houston, Texas.

M. G. Gulley, formerly situated with the Marland Oil Company at Ponca City, Oklahoma, may be addressed at Box 1214, care of K. C. Heald, Pittsburgh, Pennsylvania. Mr. Gulley is engaged in geological work in the fields of the central west for the Eastern Gulf Oil Company.

R. R. Thompson, geologist, formerly with the Texas Pacific Coal & Oil Company and the Philmack Company, has moved from 703 W. T. Waggoner Building, Fort Worth, and is now associated with Gustav Peters at 307 Petroleum Building, in a general consulting practice.

The International Petroleum Exposition which will be held at Tulsa, Oklahoma, October 20-29, is being announced in foreign countries through the Department of State, according to a joint resolution passed by the House of Representatives. Provision is made for importation of foreign articles, duty free, for the purpose of exhibition.

Chase E. Sutton, for several years petroleum engineer of the U. S. Bureau of Mines with headquarters at Dallas, Texas, may now be addressed care of Pure Oil Company, El Dorado, Arkansas.

H. D. Easton, consulting geologist of Shreveport, Louisiana, has an article on "Possibilities of Finding Oil in Western Tennessee Region," in the *Oil and Gas Journal* of May 31.

Ian Campbell, of the geological faculty of Louisiana State University at Baton Rouge, is spending the summer at Eugene, Oregon.

John P. Buwalda, professor of geology at the California Institute of Technology, has been appointed a member of a committee of three advisers to assist in the solution of problems confronting the U. S. Department of the Interior in the managing of Yosemite Valley in California.

Carroll V. Sidwell returned to the United States on March 15 after spending four years in geological and production work in Mexico with the Pan American Petroleum and Transport Company, and is now in the employ of L. H. Wentz (oil division), with offices at Eastland, Texas.

Thomas G. Madgwick has moved from Calgary to Ottawa, Ontario, Canada. He may be addressed in care of the supervisory mining engineer, Department of the Interior.

D. R. Semmes has accepted the position as assistant general manager of the recently organized Compañia Mexicana de Petroleo, "El Charro" S. A., and his address is Dept. 305, Cinco de Mayo 32, Mexico, D. F. Mr. Semmes has recently completed the field work for a new bulletin on the oil and gas posibilities of Alabama which will be published by the Alabama Geological Survey about the end of the year.

Vernon F. Marsters, formerly of Farmington, New Mexico, where he was connected with the Colorado Oil Lease Syndicate, Inc., of Denver, is now carrying on investigations for the Big Indian Oil & Development Company of Kansas City, Kansas, in Texas and in Kansas.

W. A. J. M. van der Gracht may be addressed in care of Baron Hammer-Purgstall, Schloss Hainfeld, Feldbach, Steiermark, Austria. Dr. van der Gracht is taking a vacation in the Styrian Alps.

Kirtley F. Mather, head of the Harvard University department of geology and author of a new book, *Old Mother Earth*, is leading a group of geology students on a tour of the Swiss Alps this summer.

The ninth annual meeting of the American Petroleum Institute will be held in Chicago, December 4, 5, and 6, 1928.

George Otis Smith, director of the U. S. Geological Survey and president of the American Institute of Mining and Metallurgical Engineers, delivered the commencement address at the Colorado School of Mines at Golden, Colorado, May 18.

L. D. Wosk, geologist with the White Eagle Oil and Refining Company with headquarters at Tulsa, Oklahoma, is in Casper, Wyoming, during the summer.

George Steiner, sole representative in America of the original Eötvös torsion balances, has returned to the United States after a trip of several months abroad. Dr. Steiner is at 66 Fifth Avenue, New York City.

Earl A. Trager, formerly with the Marland Oil Company and more recently with Earl Oliver and Company of Ponca City, has accepted the position of chief geologist with the Skelly Oil Company at Tulsa, Oklahoma.

D. DALE CONDIT has moved from Chevy Chase, Washington, D. C., to Bakersfield, California. Commencing with July 1, Mr. Condit's address is P. O. Box 916, Bakersfield.

P. B. WHITNEY, formerly of Denver, Colorado, is now with The Texas Company of California, with headquarters at Los Angeles, California.

CHARLES N. GOULD, director of the Oklahoma Geological Survey, reports that eight parties are in the field this summer. CHARLES E. DECKER and C. A. MERRITT of the University of Oklahoma are continuing their study of the Arbuckle Mountains. In June, they were accompanied by E. O. ULRICH of the U.S. Geological Survey in collecting fossils. F. A. MELTON of the University is applying the Cloos methods of investigation in measuring the tension joints in the formations of the Arbuckle and the Ouachita mountains. W. T. THOM, JR., of Princeton University, assisted by C. W. MILLER, is tracing the coal outcrops in eastern Oklahoma. JOE E. MOOS and PAUL E. SHELLY of the University of Oklahoma are collecting coal and asphalt samples and will make B. T. U. and weathering tests. A. J. FREIE of the University of Iowa is continuing his sedimentation studies of the Anadarko basin. G. G. SUFFEL of Stanford University is studying dolomite exposures in the Permian Red-beds. JOHN A. McCUTCHIN is undertaking the investigation of deep-well temperatures.

FREDERICK G. CLAPP, who is consulting petroleum engineer for the Imperial Government of Persia, has recently made an inspection of all the producing oil fields of Persia and Iraq, including the great Mesjid-i-Sulieman field and the new Haft-kel field of southern Persia, the Naft-khaneh field on the boundary between Persia and Iraq and the Baba-gurgur gusher near Kerkuk in the Mosul district. Mr. Clapp has returned to Teheran.

JOHN E. ELLIOTT, first vice-president of the A. A. P. G. and president of the Elliott Core Drilling Company of Los Angeles, California, has just completed an air tour lasting from May 10 to June 18 and covering the oil territory west of Mississippi River. The trip commenced at Los Angeles, included Pecos (via Tucson and El Paso), Abilene, Dallas, Fort Worth, Houston, Galveston, Beaumont, Shreveport, El Dorado (Arkansas), Ardmore, Tulsa, Oklahoma City, Bartlesville, Wichita, Denver, Colorado Springs, Cheyenne, and Salt Lake City, and ended at Los Angeles. Although taken by Mr. Elliott in the interests of his company this flight will prove to be of far-reaching influence in educating oil men in the advantages of mapping geology from the air. Members of the A. A. P. G. have been especially favored and benefitted by the tour. At the principal oil centers along the route, such as Fort Worth, Dallas, Houston, Shreveport, El Dorado (Arkansas), Tulsa, Wichita, and Denver, Mr. Elliott and his pilot, "Pat" Farris, were guests at special meetings of the local geologists, and outlined the features of geological observation from the air. Several of the local men were privileged to take long flights as follows: W. E. Wrather (Dallas to Houston), W. A. Williams and A. T. Schwennesen (Houston to Galveston), Dave Harris and H. E. Nash (Shreveport to El Dorado), Charles E. Clowe (Ardmore to Tulsa), R. S. McFarland and Bill White-

ford (Tulsa to Oklahoma City and return), W. B. Wilson and John Rich (Tulsa to Bartlesville), John Rich (Bartlesville to Wichita), R. S. McFarland and W. R. Hamilton (Wichita to Denver).

Geologists who enjoyed local trips in the Elliott seven-passenger biplane are included in the following list of those who went up: Mr. and Mrs. Ben Thompson, W. E. Wrather and family, Mr. and Mrs. Eugene Holman, Mrs. John Suman and son, Mr. and Mrs. Paul Vaudoit, Mr. and Mrs. Bob Ames and daughter, Bob Pack, G. E. Dorsey, Heath Robinson, W. B. Wilson, C. L. Severy and family, Mr. and Mrs. G. R. Henson, James O. Lewis and family, R. S. McFarland and family, G. C. Potter and family, Luther H. White and family, Mr. and Mrs. J. P. D. Hull, Miss Anna D. Whalen, Miss Margaret Skelton, Mrs. Sidney Powers, A. F. Truex and family, including Mr. Truex's mother who is 78, Floyd Miller, W. R. Hamilton and family, John Rich, Mrs. Wallace Pratt, E. DeGolyer, R. L. Dudley, Andrew Rowley, Mr. and Mrs. Perry Roberts, R. Van A. Mills, Mr. and Mrs. T. E. Swigart, H. W. Young, Mr. and Mrs. K. B. Nowels, E. O. Bennett, W. P. Haseman, Clark Gester, K. C. Sclater, Harold Vance, and A. S. Field.

The following figures present a quantitative record of the trip:

No. of days on tour 40
No. of days ship flown 31
No. of hours ship flown 81¾
No. of hours (cross country) 55
No. of landings 93
No. of passengers carried 362
No. of forced landings acct. weather . . . 2 (Abilene and Evanston)
No. forced landings acct. motor . . . . None
No. of air miles (across country) . . . 4,500

By means of this one air trip, Mr. Elliott has given many geologists first-hand evidence of the advantages of the airplane in geological work. He met approximately 400 geologists, and, as an officer of the Association, was able to carry out President McFarland's policy of closer relations between the executive committee and the individual members in the several districts. The local meetings at Wichita and Denver, in particular, where both Mr. McFarland and Mr. Elliott were present, demonstrated the active local interest in Association affairs.

PROFESSIONAL DIRECTORY

ADDRESS: J. P. D. HULL, BUSINESS MANAGER
BOX 1852, TULSA, OKLAHOMA

GEORGE STEINER
GEOLOGIST
66 FIFTH AVENUE
NEW YORK, N. Y.

SOLE REPRESENTATIVE OF THE ORIGINAL EÖTVÖS TORSION BALANCES IN AMERICA

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PETROLEUM GEOLOGISTS AND ENGINEERS
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PETTY GEOPHYSICAL ENGINEERING COMPANY
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ESPERSON BUILDING HOUSTON, TEX.

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GEOLOGIST
81 NEW STREET NEW YORK

DIRECTORY OF GEOLOGICAL SOCIETIES

ADDRESS: BUSINESS MANAGER
BOX 1852, TULSA, OKLAHOMA

PANHANDLE GEOLOGICAL SOCIETY

AMARILLO, TEXAS

PRESIDENT - - - JOHN L. FERGUSON
AMERADA PETROLEUM CORP.

VICE-PRESIDENT - - - - J. J. MAUCINI
MARLAND PRODUCTION CO.

VICE-PRESIDENT - - - - L. M. OLES
PRAIRIE OIL AND GAS CO.

SECRETARY-TREASURER - LAURENCE R. HAGY
HAGY & HARRINGTON

MEETINGS: FIRST AND THIRD FRIDAY EVENINGS EACH MONTH. PLACE: MID-WEST OFFICES, RULE BUILDING

NORTH TEXAS GEOLOGICAL SOCIETY

WICHITA FALLS, TEXAS

PRESIDENT - - - - THORNTON DAVIS
610 WAGGONER BUILDING

VICE-PRESIDENT - - - - JOHN KAY
CONTINENTAL OIL COMPANY

SECRETARY-TREASURER - - U. B. HUGHES
814 CITY NATIONAL BANK BUILDING

MEETINGS: SECOND AND FOURTH SATURDAYS EACH MONTH, AT 6:30 P. M.

PLACE: WICHITA CLUB, CITY NATIONAL BANK BLDG.

TULSA GEOLOGICAL SOCIETY

TULSA, OKLAHOMA

PRESIDENT - - - - - - L. L. FOLEY
MID-KANSAS OIL & GAS CO.

VICE-PRESIDENT - - - - R. H. DOTT
MID-CONTINENT PETROLEUM CORP.

SECRETARY-TREASURER - - E. O. MARKHAM
CARTER OIL CO.

MEETINGS: FIRST AND THIRD MONDAYS EACH MONTH, AT 8:00 P. M., IN AUDITORIUM OF MUNICIPAL BUILDING. LUNCHEONS: EVERY THURSDAY, FOURTH FLOOR, TULSA BUILDING.

KANSAS GEOLOGICAL SOCIETY

WICHITA, KANSAS

PRESIDENT - - - - - JOHN R. REEVES
EMPIRE OIL & REFINING CO.
OIL HILL, KANSAS

VICE-PRESIDENT - RICHARD B. RUTLEDGE
BARNSDALL OIL COMPANY

SECRETARY-TREASURER - ANTHONY FOLGER
GYPSY OIL COMPANY

REGULAR MEETINGS 12:30 P. M., AT INNES TEA ROOM, THE FIRST SATURDAY OF EACH MONTH. VISITING GEOLOGISTS ARE WELCOME.

THE KANSAS GEOLOGICAL SOCIETY SPONSORS THE WELL LOG BUREAU WHICH IS LOCATED AT 719-20 UNION NATIONAL BANK BUILDING.

THE SHREVEPORT GEOLOGICAL SOCIETY

SHREVEPORT, LOUISIANA

PRESIDENT - - - GEORGE R. STEVENS
SIMMS OIL CO., RICOU-BREWSTER BLDG.

VICE-PRESIDENT - - - - C. C. CLARK
ROXANA PETR. CORP., GIDDENS-LANE BLDG.

SECRETARY-TREASURER - - C. D. FLETCHER
GULF REFINING CO., ARDIS BLDG.

MEETS THE FIRST FRIDAY OF EVERY MONTH, ROOM 605, SLATTERY BUILDING. LUNCHEON EVERY MONDAY, WASHINGTON HOTEL.

HOUSTON GEOLOGICAL SOCIETY

HOUSTON, TEXAS

PRESIDENT - - - - FRANK W. DEWOLF
LOUISIANA LAND & EXPLORATION COMPANY

VICE-PRESIDENT - - LAURA LEE WEINZIERL
POST-DISPATCH BUILDING

SECRETARY-TREASURER - - MARCUS A. HANNA
GULF PRODUCTION COMPANY

REGULAR MEETINGS: FIRST FRIDAY OF EACH MONTH AT NOON IN THE UNIVERSITY CLUB. FREQUENT SPECIAL MEETINGS CALLED BY EXECUTIVE COMMITTEE.

AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

OFFICERS FOR THE YEAR ENDING MARCH, 1929

R. S. McFARLAND, *President*
Tulsa, Oklahoma

G. C. GESTER, *Past-President*
San Francisco, California

JOHN E. ELLIOTT, *First Vice-President*
Los Angeles, California

DAVID DONOGHUE, *Second Vice-President in Charge of Finances*
Fort Worth, Texas

JOHN L. RICH, *Third Vice-President in Charge of Editorial Work*
Ottawa, Kansas

DISTRICT REPRESENTATIVES

Amarillo:	C. MAX BAUER (1930), Amarillo, Texas
Appalachian:	K. C. HEALD (1929), Pittsburgh, Pennsylvania
Ardmore-Oklahoma City:	S. H. WOODS (1930), Ardmore, Oklahoma
Canada:	O. B. HOPKINS (1930), Toronto, Canada
Capital:	H. D. MISER (1931), Washington, D. C.
Dallas:	WILLIS STORM (1931), Dallas, Texas
Enid:	GLENN C. CLARK (1931), Ponca City, Oklahoma
Fort Worth:	H. B. FUQUA (1930), Fort Worth, Texas
Great Lakes:	A. C. TROWBRIDGE (1929), Iowa City, Iowa
Houston:	J. M. VETTER (1929), Houston, Texas
Mexico:	S. A. GROGAN (1929), Tampico, Mexico
New York:	W. B. HEROY (1929), White Plains, New York
Pacific Coast:	C. R. McCOLLOM (1931), Los Angeles, California N. L. TALIAFERRO (1930), Berkeley, California C. M. WAGNER (1929), Los Angeles, California
Rocky Mountains:	ALEX. W. McCOY (1931), Denver, Colorado CHARLES M. RATH (1929), Denver, Colorado
San Angelo:	EDGAR KRAUS (1929), San Angelo, Texas
Shreveport:	W. E. HOPPER (1930), Shreveport, Louisiana
South America:	J. B. BURNETT (1930), Maracaibo, Venezuela, S. A.
Tulsa:	SIDNEY POWERS (1931), Tulsa, Oklahoma ROBERT J. RIGGS (1930), Bartlesville, Oklahoma A. F. TRUEX (1929), Tulsa, Oklahoma
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